April 11, 1967 M. F. THOMPSON 3,313,209

ARTILLERY FIRE CONTROL SYSTEM

Filed June 24, 1965 4 Sheets-Sheet 1

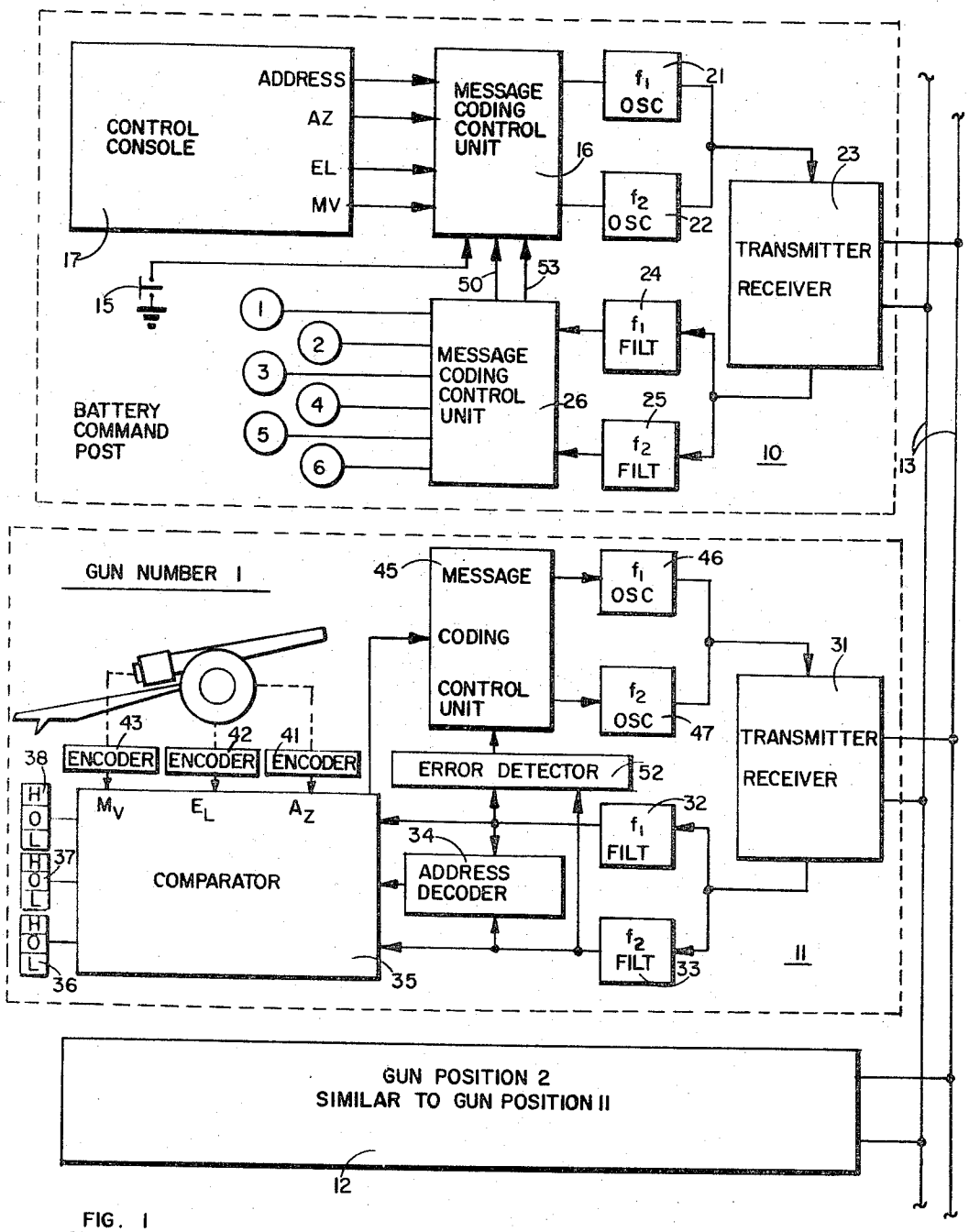


FIG. 1

INVENTOR.
MALCOLM F. THOMPSON

BY A M Fernandez

ATTORNEY

April 11, 1967 M. F. THOMPSON 3,313,209

ARTILLERY FIRE CONTROL SYSTEM

Filed June 24, 1965 4 Sheets-Sheet 2

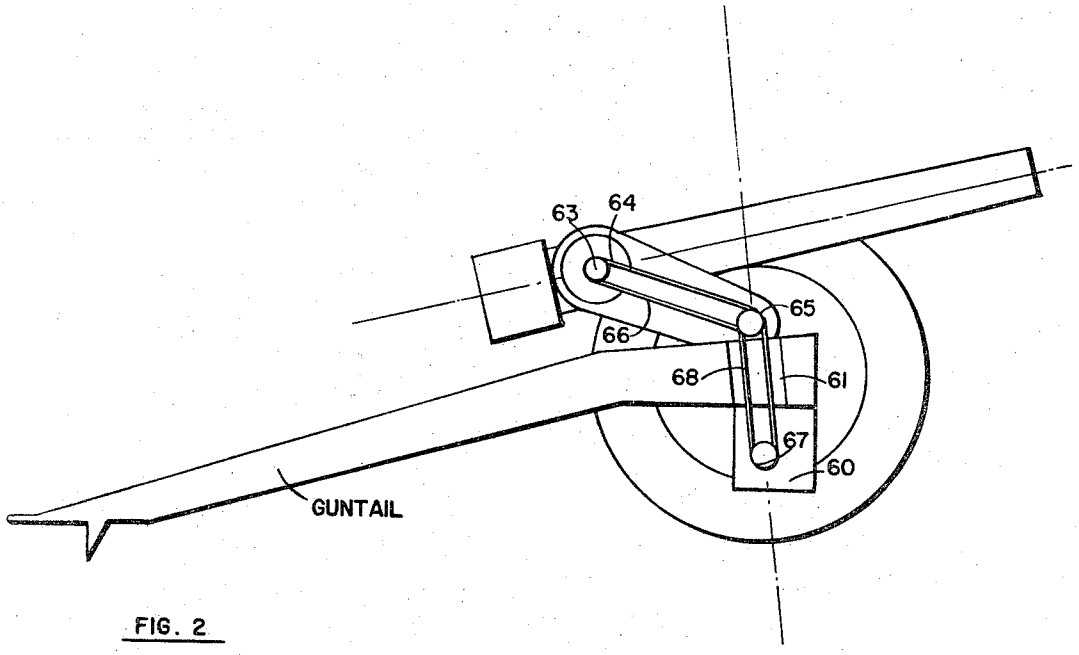


FIG. 2

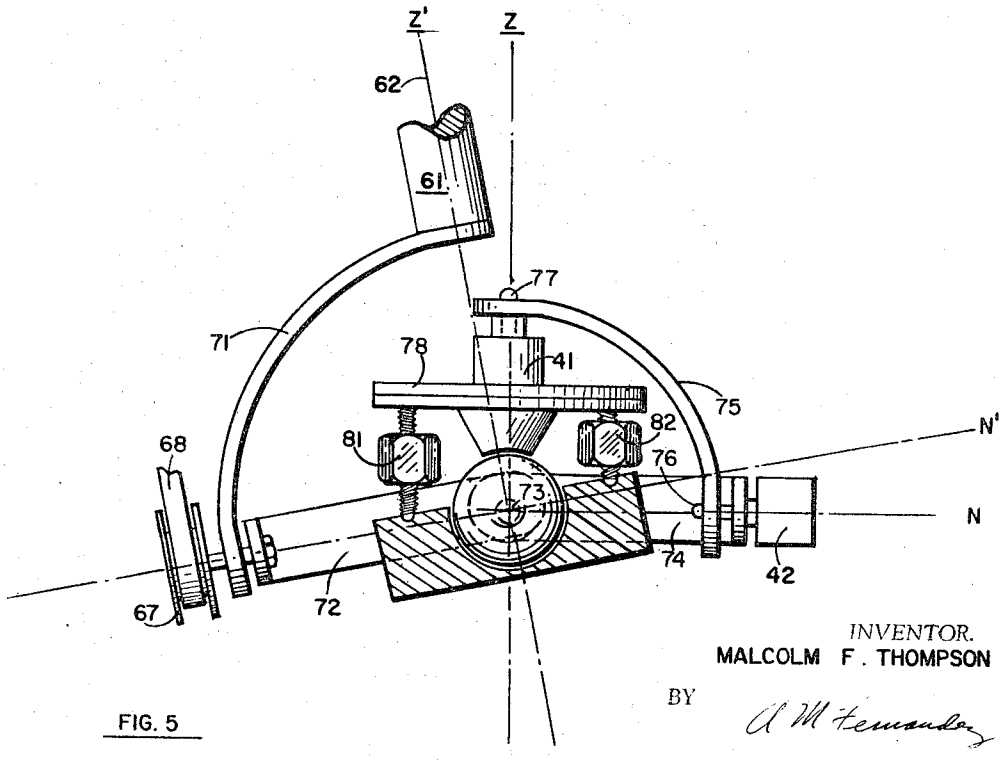


FIG. 5

INVENTOR.
MALCOLM F. THOMPSON

BY A M Fernandez

ATTORNEY

April 11, 1967 M. F. THOMPSON 3,313,209

ARTILLERY FIRE CONTROL SYSTEM

Filed June 24, 1965 4 Sheets-Sheet 3

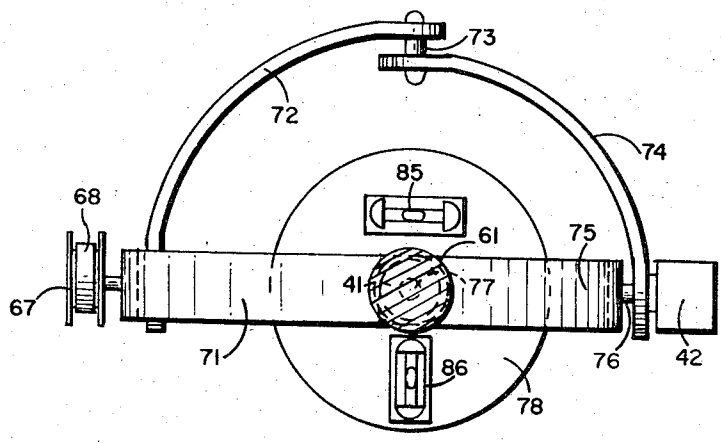


FIG. 4

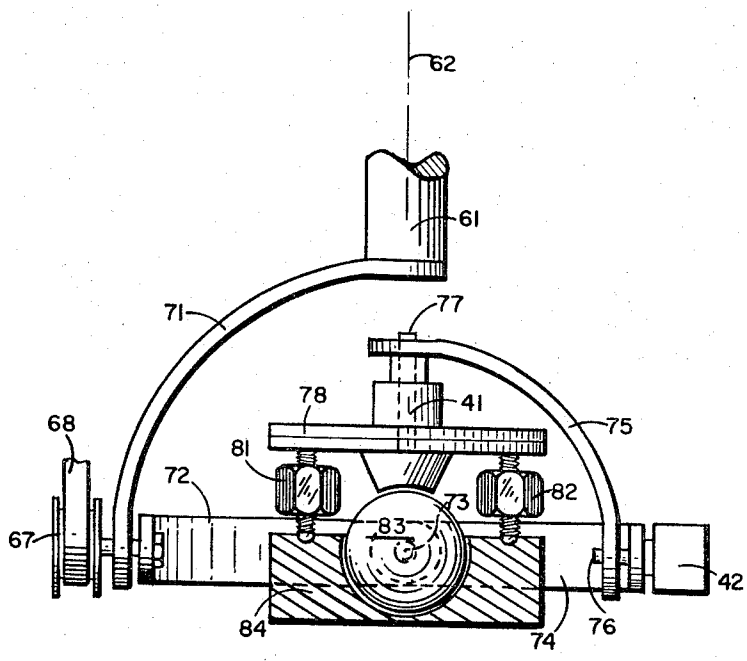


FIG. 3

INVENTOR.
MALCOLM F. THOMPSON

BY

ATTORNEY

April 11, 1967 M. F. THOMPSON 3,313,209

ARTILLERY FIRE CONTROL SYSTEM

Filed June 24, 1965 4 Sheets-Sheet 4

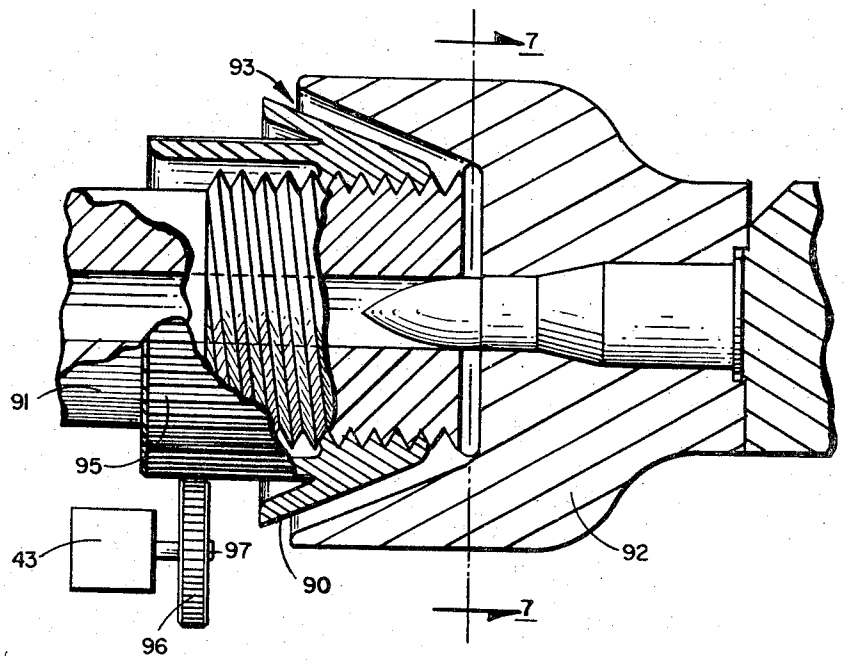


FIG. 6

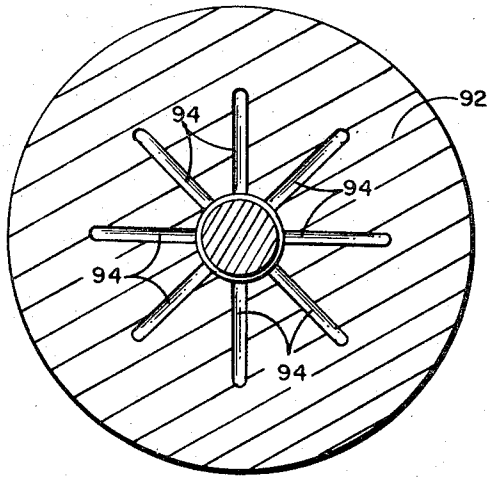


FIG. 7

INVENTOR.
MALCOLM F. THOMPSON

BY

ATTORNEY

United States Patent Office 3,313,209
Patented Apr. 11, 1967

3,313,209

ARTILLERY FIRE CONTROL SYSTEM

Malcolm F. Thompson, Santa Ana, Calif., assignor to North American Aviation, Inc.

Filed June 24, 1965, Ser. No. 466,613
3 Claims. (Cl. 89—41)

This invention relates to a fire control system for artillery and more specifically to a system for the automatic transmission of fire control data to remote gun positions, and automatic transmission of messages to the battery command post from remote gun positions indicating that the guns have been properly laid.

The accurate transmission of fire control commands between the battery executive at a command post and gun crews at remote gun positions is desirable for the correct laying of the guns and quick verification by the executive that the guns have been properly laid. It has been discovered that the operations involved could be executed more efficiently with minor modifications to existing equipment including a two-wire telephone line for communications between the battery command post and all of the remote gun positions.

Present day field artillery weapons are optically sited in azimuth and laid in elevation from a bubble level. Voice commands have been employed to accomplish this using field telephones to reach remote gun positions. The possibility of error exists in such voice communications, both in the transmission and in the interpretation of the commands, due to the human element involved. Faster and more accurate fire control could be established by automatic transmission of fire control data to the guns, and transmission to the command post of verification that the guns have been properly laid.

Another problem encountered in the past relates to maintaining an optimum high angle trajectory for varying ranges by varying the powder charge for various ranges. Faster reaction time and a greater firing rate could be maintained if fixed ammunition could be employed for all ranges with optimum high angle trajectory for each. If a variable muzzle velocity could be obtained with fixed ammunition, all gun laying commands could be quickly transmitted in terms of azimuth, elevation and muzzle velocity in such a way as to allow each variable to be similarly adjusted until all variable elements of the gun correspond to the commands received.

An object of this invention is to provide a system for the automatic transmission of fire control commands to a gun at a remote position from a command post and for automatic verification at the command post that the gun has been properly laid.

Another object of the invention is to provide automatic transmission of fire control commands to a plurality of guns at remote positions and automatic verification at the command post that the individual guns have been properly laid.

Another object is to provide automatic transmission of fire control commands to a selected one of a plurality of guns and automatic verification that the gun selected has been properly laid.

Another object is to provide automatic transmission of individual fire control commands to selected ones of a plurality of guns and automatic verification that the guns selected have been properly laid.

Still another object is to provide a system for the automatic transmisison of fire control data including muzzle velocity and automatic verification that the gun has been properly laid in all respects including the muzzle velocity.

A more specific object of the invention is to provide a system for the automatic transmission of fire control commands to a gun at a remote position and automatic

interpretation and comparison of the commands with compliance therewith, and automatic indication of the compliance to allow the gun laying crew to so adjust the variables of the gun as to provide compliance with the fire control commands and as a further object to automatically transmit to the command post a message that the gun has been properly laid when each of the variables of the gun has been adjusted to the position indicated by the gun laying command.

These and other objects of the invention are achieved in a system in which fire control commands for remote gun positions are either manually entered or calculated by a computer at a battery command post, and automatically transmitted in digital form to the guns over a single two-wire communication channel. The gun laying command message for a given gun consists of the gun address, azimuth, elevation and, if desired, muzzle velocity. Each message is transmitted over the two-wire communication channel to all remote gun positions where the address portion is decoded. Only that gun being addressed responds to the address portion of the message to enable a comparator to receive the gun laying commands which follow for comparison with the azimuth, elevation and, if required, muzzle velocity setting of the gun. The comparator visually displays to the gun crew when the gun setting is too high, too low or on target with respect to elevation and, if required, muzzle velocity, and too far right, too far left or on target with respect to azimuth. A coordinate converter is provided to convert gun deflection and elevation to true azimuth and elevation for direct comparison with the azimuth and elevation commands.

When the gun is properly set with respect to all variables, the comparator causes a message to be transmitted to the battery command post. The message comprises the address of the gun; its meaning that the gun has been properly laid is implied. The command post receives the message and displays it. If more than one gun is being employed, the battery executive may withhold the command to fire until all of the guns have been properly laid. He may however issue the command to fire the guns individually as verification is received that the guns have been properly laid. This verification is provided by visual display devices, one for each gun, energized individually when the guns transmit messages indicating that they have been properly laid.

Other objects and advantages of the invention will become apparent from the following description with reference to the drawings in which:

FIGURE 1 is a block diagram of an illustrative embodiment of the invention;

FIGURE 2 illustrates the manner in which the gun barrel elevation axis may be translated to a parallel position which intercepts the deflection axis of the gun;

FIGURE 3 illustrates a side view, partly in section, of a device for converting gun elevation and deflection with respect to the mutually perpendicular gun trunnion and gun deflection axis to true elevation and azimuth;

FIGURE 4 is a top view of the device of FIGURE 3;

FIGURE 5 illustrates the manner in which the device of FIGURE 3 is employed to provide a true horizontal and vertical reference for a given trunnion tilt angle;

FIGURE 6 shows in cross-section a variable porting arrangement for adjusting the muzzle velocity of a gun using fixed ammunition; and

FIGURE 7 is a cross-section taken along the line 7—7 of FIGURE 6.

The general system organization of the present invention is illustrated schematically in FIGURE 1 as comprising a battery command post **10** and a plurality of gun positions **11** and **12**, all of which are connected to a pair

of field telephone wires **13**. Since all of the gun positions are similar, only one has been illustrated schematically in block diagram form. The second gun position **12** is identical to the gun position **11** except as will be explained hereinafter, adapted to respond to a different address code. Additional gun positions may be similarly connected to the telephone wires **13**.

The battery command post and gun positions transmit and receive over the single pair of field telephone wires **13**. The gun laying commands are transmitted from the battery command post to all of the gun positions as binary coded messages. A given message sent from the battery command post **10** to a particular gun position, such as the gun position **11**, consists of at least 13 binary-coded-decimal (BCD) characters. The first BCD character of the message is the numerical address of the gun position.

An artillery fire unit usually includes only six gun positions so that a single BCD character is sufficient to uniquely address each of the gun positions. However, if a larger number of gun positions are to be controlled by the same battery command post, the address portion of the message may be expanded to more than one BCD character.

The address of the gun position is followed by the azimuth and elevation command, and if desired, a muzzle velocity command, each of which comprises four BCD characters. The message is transmitted serially starting with the least significant BCD character of the gun address and concluding with the most significant BCD character of the muzzle velocity command. If parity error detection is included, each message or portion thereof, may be terminated by a binary parity digit in a manner well known to those skilled in the art.

When it is desired to send a message from the battery command post, an initiate switch **15** is actuated to cause a signal to be sent to a message coding control unit **16** which sequences the transmission of the message in the order indicated, namely address code followed by commands for azimuth, elevation, and if included, muzzle velocity. The message to be transmitted is composed at a console **17**, either manually by the battery executive officer on instructions from a fire direction center (not shown), or by a computer included in the console which receives its data from the fire direction center.

The message coding control unit **16** includes means for producing a series of coded binary digits and synchronizing signals. These signals are applied to a pair of oscillators **21** and **22** that control the output of a transmitter-receiver **23** which preferably comprises a hybrid transformer of the type employed in two-wire telephone communications, with one amplifier between the oscillators **21** and **22** and the hybrid transformer for amplifying transmitted messages, and another amplifier between the hybrid transformer and a pair of selected bandpass filters **24** and **25** for amplifying messages received over the telephone lines **13**. Thus the hybrid transformer having its two-wire output connected to the telephone lines **13** will allow two-way communication between the battery command post and any one of the gun positions without the battery command post receiving its own message.

As the message coding control unit **16** affects the transmission of the message, it routes digits of one binary value to one oscillator and digits of the other binary value to the other oscillator, such as the binary-zero digits to the oscillator **21** and the binary-one digits to the oscillator **22**. Each binary digit received by the oscillators **21** and **22** will trigger the associated oscillator to cause it to transmit a signal of one frequency or the other of the two frequencies f_1 and f_2 selected for the oscillators **21** and **22**. This frequency-shift coding of the message is preferred, although generally more prodigal of bandwidth than phase-shift modulation, in order to provide a less complex, and therefore less expensive, transmitter-receiver **23**. However, it should be understood that any pulse code communication system known may be employed such as phase-shift or amplitude modulation systems. Thus each digit transmitted consists of a short pulse of one or the other of the two frequencies f_1 and f_2, each for a predetermined length of time. The synchronizing signals may consist of longer pulses of a selected one of the frequencies f_1 and f_2 or combinations thereof.

When the gun crew at the gun position being addressed has complied with all commands of the message the gun position automatically transmits a message over the telephone lines **13** to the battery command post. That message consists of simply the address of the transmitting gun position, it being understood that the transmission of gun position address to the command post means that the gun has been properly laid as commanded. However, the message may consist of the gun position address and one or more binary coded words. In any case, the message is received over the transmitter-receiver **23** and filters **24** and **25** which identify the binary digits zero and one, respectively.

The message decoding control **26** receives the binary digits from the filters **24** and **25** over separate lines and combines them for decoding. Once the message has been decoded, a visual display indicator corresponding to that gun position is energized. For instance, if the gun position **11** is designated Gun No. 1, a gun laying command received and executed by that gun position causes its address code to be transmitted to the battery command post where it is decoded to energize indicator **1**. Once the battery executive officer sees that the visual display indicator **1** has been energized, he may issue the order to fire Gun No. 1 by voice communication over the telephone lines **13**.

At each gun position, the message transmitted by the battery command post is received over a transmitter-receiver **31** identical to the transmitter-receiver **23** of the battery command post **10**. A pair of filters **32** and **33** distinguish the binary digits of the received message in the same manner as filters **24** and **25** of the command post. As noted hereinbefore, the first portion or word of the message is a binary-coded-decimal number identifying the gun being addressed. An address decoder **34** receives the binary digits from the filters **32** and **33** and determines whether that gun position is being addressed. Accordingly, the address decoder **34** is conditioned to detect only the address code assigned to its gun position. That may be readily accomplished by a four-bit shift register adapted to receive the binary digits from the filters **32** and **33** so that when the entire binary-coded-decimal number for the gun position has been received, the contents of the shift register may be examined in parallel through a diode decoding matrix programmed through a plugboard (not shown) to identify the BCD number. Alternatively, the decoding function may be carried out by serially comparing the digits of the received BCD number with a stored number as by effectively subtracting the received number from the stored number. To facilitate that, the stored number may be in the 2's complement form so that the subtraction may be carried out by a serial binary adder; the difference is then immediately tested to determine whether it is zero.

Once the address portion of the message has been identified by the address decoder **34**, it transmits a control signal to a comparator **35** which is then enabled to receive the remaining portion of the message consisting of the azimuth, elevation, and if included, muzzle velocity commands for the gun. The individual commands received by the comparator **35** are compared with the actual settings of the gun read out in digital form through binary-coded-decimal converters or encoders **41**, **42** and **43**. The comparator **35** may be attached to the gun in a convenient location with three error displays **36**, **37** and **38** so mounted as to be readily viewed by members of the gun crew. For instance, the elevation setting of the gun is

read out through the encoder 41 and compared with the elevation command. If the elevation setting is greater than the elevation command, a "high" or "H" indication is displayed to the crew member who trains the gun in elevation. The display device 37 will similarly indicate when the elevation setting is less than the command by displaying a "low" or "L" indication. When the elevation setting is equal to the elevation command, the indicator 37 displays an "on target" or "O" indication. The display devices 36 and 38 perform similar functions except that the display device 36 associated with the azimuth setting of the gun will display a "left" or "L" indication when the gun deflection setting is greater than the azimuth command.

The comparator compares the gun laying commands in the order received with the settings read out through the encoders 41, 42 and 43. As each comparison is made, the corresponding error display device is set to indicate whether the gun is laid too high (or too far right) or too low (or too far left). The gun crew then adjusts the gun accordingly. In the meantime, the comparator will not transmit a signal to a message coding control unit 45. After a predetermined delay period of less than one second, the battery command post automatically retransmits the same message.

When the battery command post is communicating with only one gun, it retransmits the same message until the comparator 35 at that gun position being addressed determines that the gun is properly laid in azimuth, elevation, and if required, muzzle velocity. Once the gun is properly laid, the indicators 36, 37, 38 announce that to the gun crew and the comparator transmits a signal to the message coding control unit 45 which then transmits a message indicating the gun has been properly laid. Transmission of the "on target" message is accomplished by frequency shift coding through oscillators 46 and 47 in the same manner that messages are transmitted by the battery command post.

With a communication pulse rate of 1000 binary digits per second, a complete message from the battery command post to a gun position including azimuth, elevation and muzzle velocity commands would require less than 60 milliseconds. If the same amount of time is allotted for a reply from the gun position, the message coding control unit 16 at the battery command post 10 may automatically retransmit the message every 120 milliseconds, or 8 times per second. Once the gun has been properly laid and an "on target" message has been received by the message decoding control unit 26, a signal is transmitted over a line 50 to the message coding control unit 16 to terminate transmission of the message.

If the battery command post is transmitting the same gun laying commands to all of the guns, for example all six guns in the unit assigned to the battery command post, the message coding control unit 16 will cycle through the individual messages for all of the guns pausing after each message transmission to receive an "on target" message indicating that the gun just addressed is properly laid. In that manner, the message coding control unit 16 will cyclically transmit all of the messages until all guns are properly laid. For that mode of operation, the message decoding control unit 26 will not transmit a signal over the line 50 to stop transmission of messages until an "on target" message has been received from each of the guns and all of the visual indicators 1 through 6 at the battery command post 10 have been energized.

If parity error detection, or any other system of error detection is provided, an error detector 52 may be connected to both the address decoder 34 and the comparator 35 at the gun position 11 in order that error detection of both the address code and the azimuth, elevation and muzzle velocity commands may be checked. If an error is detected, the error detector 52 will cause the message coding control unit 45 to transmit only an error message immediately after transmission from the battery command post 10 to the gun position 11 has been completed. Any error message received by the transmitter-receiver 23 of the battery command post 10 is then decoded by the message decoding control unit 26 which transmits a signal over a line 53 to cause the last message to be retransmitted.

The azimuth and elevation commands transmitted to a gun position are in terms of true azimuth and true elevation. If the gun is level so that the gun trunnion is horizontal and the gun deflection axis is vertical, the azimuth and elevation encoders 41 and 42 may be read and directly compared with the azimuth and elevation commands. However, as is usually the case, the gun is not level. Therefore in order to be able to make a direct comparison of azimuth and elevation commands with the output of the encoders 41 and 42, a coodinate converter is required between the gun and the encoders 41 and 42 to eliminate the error which would otherwise appear both in azimuth and elevation. In that manner, the encoders 41 and 42 transmit the true azimuth and elevation angles for direct comparison with the azimuth and elevation commands regardless of whether the gun is level.

A suitable coordinate converter 60 will now be described with reference to FIGURES 2, 3 and 4. In order to device a coordinate converter which is both inexpensive and reliable, the coordinate converter 60 is connected directly to the gun deflection pintle 61. Since the deflection axis 62 does not intercept the axis of elevation, which is the axis of the gun trunnion 63, it is necessary to first translate the elevation axis to a position which does intercept the deflection axis. This is accomplished by providing a first pulley 64 (FIGURE 2) on the gun trunnion and a second pulley 65 on the deflection pintle 61 with the axis of the second pulley 65 intercepting the deflection axis 62. A taut band 66 will cause the elevation of the gun about the trunnion axis 63 to be translated to the pulley 65. A third pulley 67 and a second band 68 translates the gun elevation axis down to the coordinate converter 60.

In the coordinate converter 60 illustrated in FIGURES 3 and 4 a first gimbal-like member 71 maintains the axis of rotation of the pulley 67 perpendicular to the deflection axis 62 so that as the pintle 61 rotates to train the gun in azimuth, the pulley 67 moves in an arc about the axis 62. As the gun is elevated, the pulley 67 rotates about its axis. A second gimbal-like member 72 fixedly connected to the pulley 67 is caused to rotate and thereby move a pin 73 in an arc about the axis of the pulley 67 which is parallel to the gun trunnion axis. As the pin 73 moves through that arc, a third gimbal-like member 74 is also caused to rotate about an axis adjusted to be horizontal by the adjustment of a fifth gimbal-like member 75 which holds the axis of a pin 76 at one end perpendicular to the axis of a pin 77 at the other end. The pin 77 is fixedly connected to a leveling table 78 and the gimbal-like member 75 is journaled to rotate about the axis of the pin 77.

Leveling screws 81 and 82 are provided to adjust the leveling table 78 about a sphere 83 which is fixed in position on the gun mount 84 with its center on the deflection axis 62. The leveling screws 81 and 82 are adjusted until the axis of the pin 76 is horizontal as indicated by a bubble level 85 as shown in the top view of FIGURE 4. Another pair of leveling screws, not shown in the side view of FIGURE 3, are then adjusted until the axis of the pin 77 is vertical as indicated by the spirit levels 85 and 86. Once these adjustments have been made, true azimuth and elevation can be read from encoders 41 and 42, respectively.

In FIGURES 3 and 4, the true elevation and azimuth axis coincide with the gun deflection axis 62 and the axis of the pulley 67 because the gun is level. Accordingly, motion of the gun in deflection and elevation is translated directly to the azimuth and elevation posi-

tion encoders 41 and 42, respectively, without conversion. However, this special condition will illustrate the manner in which the coordinate converter operates. As the gun is trained in deflection about the axis 62, the gun deflection pintle 61 will cause the pulley 67 to be moved through an arc of the same angle as the gun deflection. The second and third gimble-like members 72 and 74 will then cause the fourth gimbal-like member 75 to rotate through an arc of the same angle. In that manner, the true deflection of the gun is read directly from the encoder 41. As the gun is trained in elevation the pulley 67 causes the pin 73 (FIGURE 4) to be moved through an arc of the same angle as the pulley 67. That angle is translated by the third gimbal-like member 74 to the elevation encoder 42 so that true gun elevation is read directly.

If the gun trunnion is not horizontal, a trunnion tilt error would exist in the output from the encoders 41 and 42 were it not for the coordinate conversion provided by the four gimbal-like members. FIGURE 5 shows the positions of the first and second gimbal-like members 71 and 72 relative to the third and four gimbal-like members 74 and 75 after the leveling table 78 has been adjusted to a true level position by adjusting screws 81 and 82 (and two others not shown). As the gun is trained about the deflection axis 62, the rotation of the gun deflection pintle 61 translated through the gimbal-like members 71, 72 and 74 is converted to true gun deflection in the rotation of the gimbal-like member 75 about the axis of the pin 77. Similarly, elevation of the gun causes the pulley 67 to rotate about its axis. That rotation is then translated through the gimbal-like members 72 and 74 to the elevation encoder 42 as true elevation. The gun barrel axis is always parallel to the axis of the pin 73 (FIGURE 3) or more properly speaking parallel to the line running through the center of the sphere 83 and the pin 73, so that true azimuth and elevation can at all times be read directly from the encoders 41 and 42, respectively. This is necessarily so because the inner gimbal-like members 74 and 75 are referenced to true vertical and horizontal axis. Thus connecting the gimbal-like members 74 to the pin 73 will allow true gun elevation to be read from the angle between the gimbal-like members 74 and 75 and true azimuth to be read from the angle between a reference mark on the leveling table 78 and the position of the gimbal-like member 75 or more specifically, the axis of the pin 76.

The reference mark on the leveling table may be adjusted to coincide with true north, or some other reference point with respect to which the azimuth commands are to be given, by so constructing the leveling table as to allow the upper half to which the encoder is fixedly attached to be rotated about the axis of the pin 77.

It is desirable to use fixed ammunition for protecting against weather, and increased rate of fire. In order to use fixed ammunition and have variable muzzle velocity, the gun breach may be modified to bleed out a variable amount of the powder gasses from the chamber behind the projectile. A suitable porting arrangement is shown in FIGURES 6 and 7. FIGURE 6 is a section of the gun with a round of ammunition in place. A variable closure screw 90 is provided to adjust the porting of the powder gasses according to the muzzle velocity required. As the variable closure screw is rotated clockwise, it moves along a threaded portion of the gun barrel 91 toward the gun breach 92. As shown the variable closure screw has been rotated counter clockwise sufficiently to open a space 93 between the closure screw 90 and the breach 92 for maximum porting of the powder gasses and minimum muzzle velocity. The porting of the powder gasses is through holes 94 at the base of the gun barrel. A cross-section taken along the line 7—7 is shown in FIGURE 7 to illustrate the pattern of eight porting holes at the base of the gun barrel. The number and size of the porting holes required would depend upon the particular gun and minimum muzzle velocity desired with a specified powder charge in the fixed ammunition.

As the closure screw 90 is rotated clockwise, the space 93 is decreased thereby decreasing the amount of powder gasses bled out through the porting holes. A splined sleeve 95 attached to the variable closure screw is engaged by a gear wheel 96 fixedly attached to a shaft 97 which is connected to the muzzle velocity encoder 43. In that manner variable porting for variable muzzle velocity can be incorporated in this system for accurate transmission of fire control commands between the battery executive officer at a command post and gun crews at remote gun positions not only for gun laying in azimuth and elevation but also for muzzle velocity.

The indicator 38 (FIGURE 1) is provided to indicate to the gun crew when the muzzle velocity setting is too high or too low in the same manner as the indicator 37 indicates to the gun crew when elevation is too high or too low. Once all three position encoders 41, 42 and 43 compare with the commands in azimuth, elevation and muzzle velocity, and not until then, the gun may be said to be properly laid. Thus the comparator will cause the message coding control unit 45 to transmit an on target message from the gun position to the battery command post only when muzzle velocity is properly adjusted in this manner. If the powder charge is varied instead, the muzzle velocity encoder 43 would either not be provided or else would be manually set to a value which would correspond to the muzzle velocity provided by the powder charge actually placed in the gun for the next round.

While a particular embodiment of the invention has been shown, it should be understood that the following claims are not to be limited to it since many modifications may obviously be made without departing from the true spirit and scope of the invention.

What I claim is:

1. In a fire control system including a communication channel for transmitting fire commands in true azimuth and elevation between a battery command post and a gun crew and means for comparing the actual gun setting in azimuth and elevation with said commands, a coordinate converter for translating apparent azimuth and elevation derived from the actual movement of a gun about its elevation and deflection axis into true azimuth and elevation, where true azimuth is taken from an arbitrary reference point, comprising

means for translating the axis of the gun in elevation to a position which intercepts the axis of deflection in azimuth,

a first gimbal-like member coupled to the gun deflection mechanism for rotating said translated elevation axis about said axis of deflection in response to training said gun in azimuth,

a second gimbal-like member for rotating a third axis about said translated elevation axis in a plane passing through said axis of deflection,

a third gimbal-like member connected to said second gimbal-like member at said third axis, said third gimbal-like member being constrained to rotate about an axis in the same plane as the translated elevation axis,

a fourth gimbal-like member connected to said third gimbal-like member to restrain the axis of rotation of said third gimbal-like member perpendicular to a vertical axis,

leveling means for adjusting said vertical axis to true vertical, whereby training said gun in elevation and azimuth will cause said third and fourth gimbal-like members to rotate about the true elevation axis and the true azimuth axis in response to actual movement of the gun,

and angular position transducers connected to said third and fourth gimbal-like members for producing signals indicating the true elevation and azimuth of the gun.

2. In a fire control system, the combination as defined in claim 1 wherein

said first gimbal-like member is connected directly to the gun pintle for direct rotation about the deflection axis as the gun is trained in elevation,

and said means for translating the gun elevation axis is comprised of a first pulley connected for rotation with the gun trunnion about the gun elevation axis, a second pulley connected to rotate said second gimbal-like member about the translated elevation axis, and a belt system for translating angular motion of said first pulley to said second pulley.

3. In a fire control system including a communication channel for transmitting fire commands to a gun crew in true azimuth and elevation and means for comparing the actual gun setting in azimuth and elevation with said commands, a coordinate converter for translating apparent azimuth and elevation of a gun about its elevation and deflection axis into true azimuth and elevation, where true azimuth is taken from an arbitrary reference point, comprising

first means for translating the gun barrel elevation axis to a parallel position which intercepts the gun barrel deflection axis,

second means for establishing a true vertical axis and a true horizontal axis which intercept each other at the same point at which the translated elevation axis intercepts the gun deflection axis,

a first gimbal-like member mechanically coupled to the gun for direct rotation in response to gun deflection of the gun with respect to the gun carriage is always exactly equal to the angle between the first gimbal-like member and a fixed reference point,

a second gimbal-like member connected to said first means and said first gimbal-like member with its axis of rotation along the translated elevation axis

whereby the angle between said second gimbal-like member and a fixed reference is always equal to the elevation angle to the gun barrel,

means for establishing a true vertical axis intercepting the gun deflection axis at the point of interception between the gun deflection axis and the translated elevation axis,

a third gimbal-like member mounted for rotation about said true vertical axis,

a fourth gimbal-like member mounted for rotation about an axis perpendicular to said true vertical axis and intercepting said true vertical axis where said true vertical axis intercepts said gun deflection axis,

and a pin rotably connecting said second and fourth gimbal-like members at a point along an axis perpendicular to both the axis of rotation of said second gimbal-like member and the axis of rotation of said fourth gimbal-like member, whereby: said axis along which said pin rotatably connects said second and fourth gimbal-like members is always parallel to the gun barrel axis; true azimuth of the gun barrel is always equal to the angle between said third gimbal-like member and said arbitrary reference; and true elevation is always equal to the angle between said fourth gimbal-like member and a fixed reference.

References Cited by the Examiner

UNITED STATES PATENTS

1,077,965	11/1913	Pollen et al.	89—41
1,373,793	4/1921	Akemann	89—41
1,722,923	7/1929	Just et al.	89—41
2,700,106	1/1956	Taylor	89—41 X
2,801,416	8/1957	Evans et al.	89—1 X

SAMUEL W. ENGLE, *Primary Examiner.*