May 27, 1947. S. N. WIGHT ET AL 2,421,106

AIRWAY TRAFFIC CONTROL SYSTEM

Filed Jan. 21, 1943 3 Sheets-Sheet 1

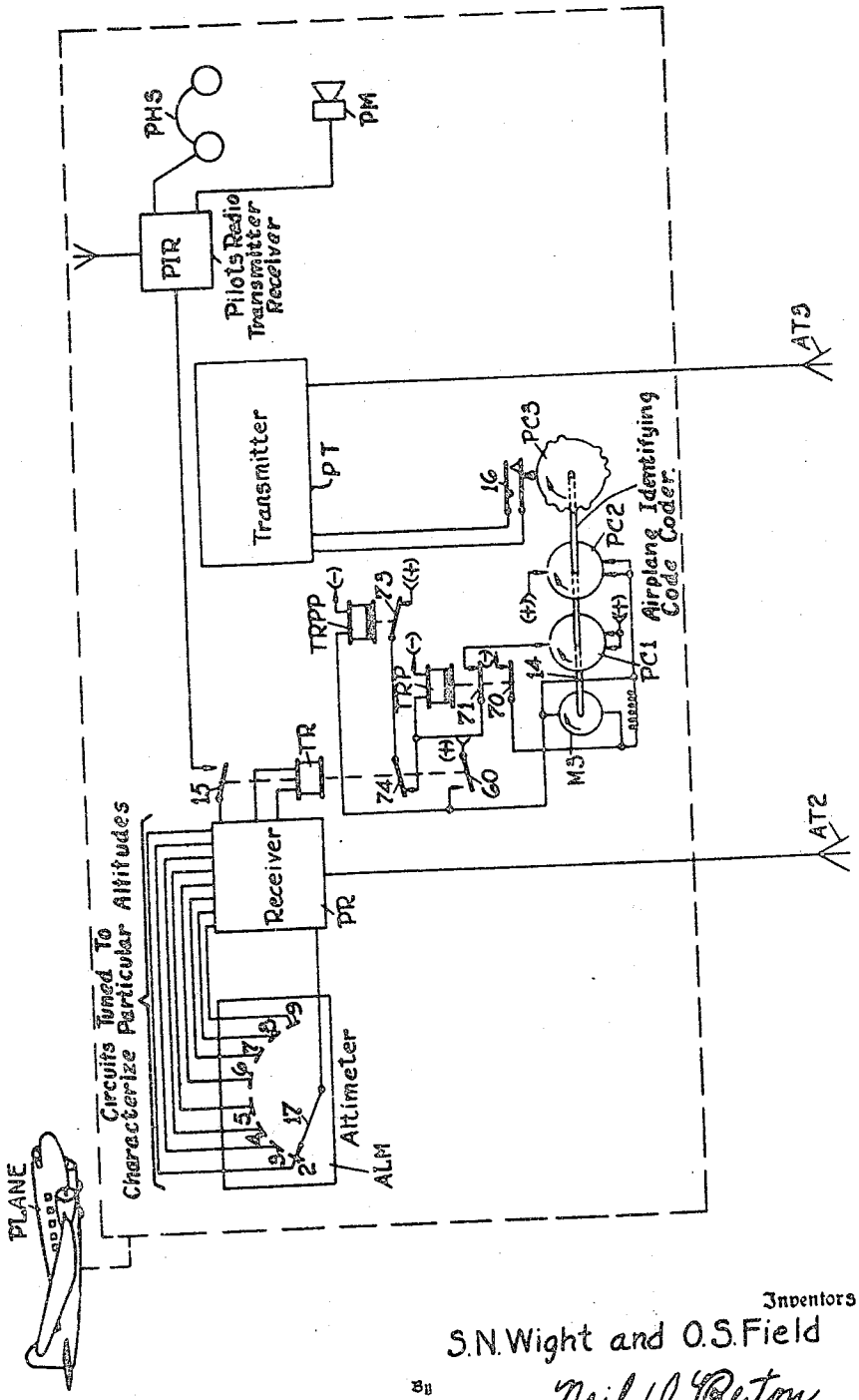

FIG. 1A.

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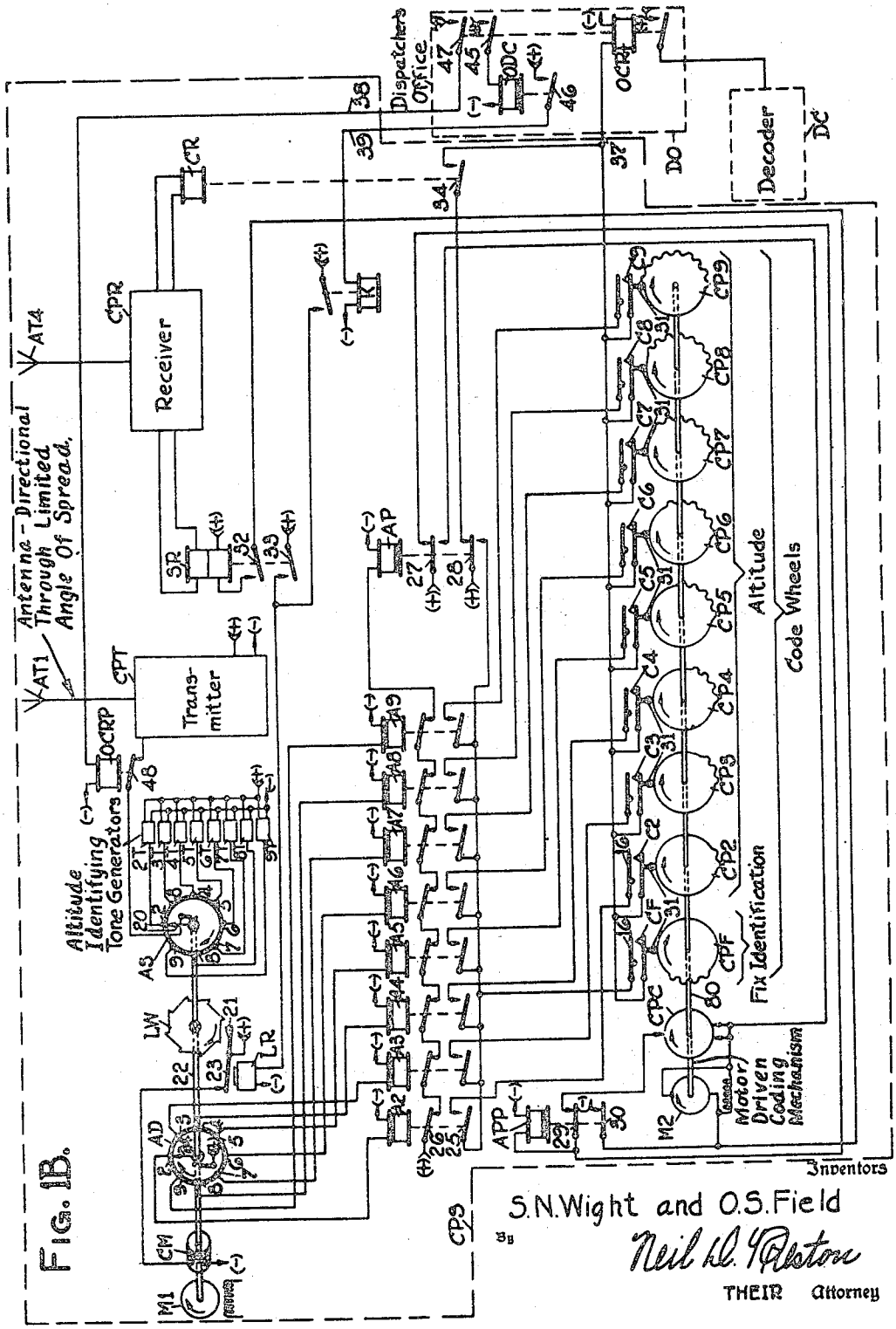

FIG. 1B.

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Filed Jan. 21, 1943 3 Sheets-Sheet 3

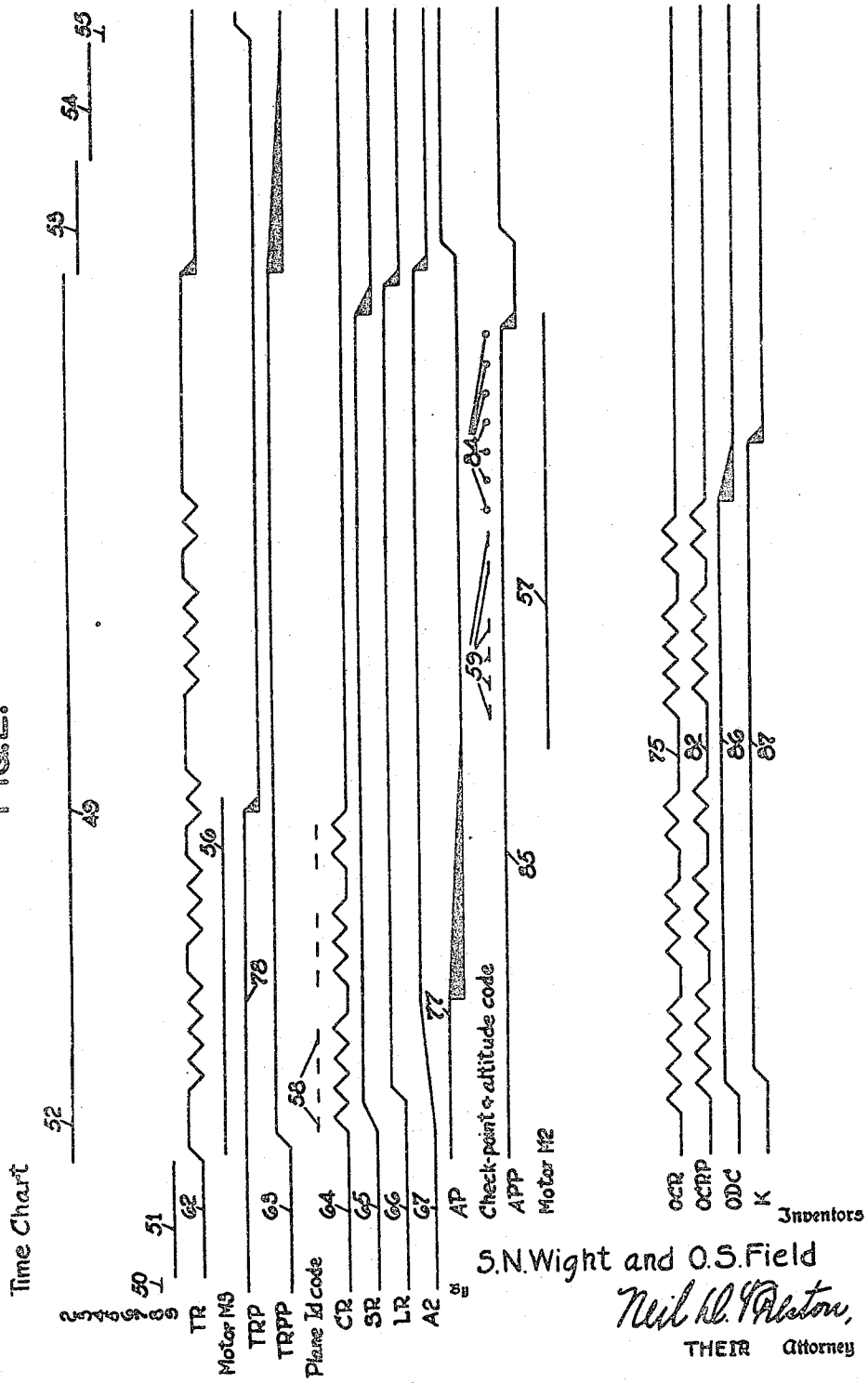

FIG. 2.

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UNITED STATES PATENT OFFICE

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AIRWAY TRAFFIC CONTROL SYSTEM

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Application January 21, 1943, Serial No. 473,096

26 Claims. (Cl. 177—353)

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The present invention relates to apparatus for automatically reporting the identification, location and/or the altitude of airplanes.

In the dispatching of airplane traffic, by authorizing such airplanes to travel over specified ground routes at specified altitudes on various stretches thereof, it is essential that the whereabouts of airplanes already given authorization to fly in the vicinity be definitely known.

Although pilots of airplanes flying over commercial air routes are seldom lost because radio range legs or courses guide them over the ground route, radio fixes and radio fan markers inform them when they have reached certain check-points or stations along the air route and altimeters inform them of their altitude, there is a possibility that a pilot may not know what radio fix he is passing over. For reasons of safety, the dispatcher should be informed of the location, identity and altitude of each airplane by mechanical and electrical apparatus automatically so that wrong indications or reports due to failure of the human element are avoided.

In view of the foregoing and other considerations, it is proposed in accordance with the present invention to provide apparatus, at each radio fix, check-point or ground location, which by radio communicating apparatus will communicate with airplanes flying over such particular check-point only at one altitude at a time, so that if a plurality of airplanes fly over the same check-point at different altitudes, as is possible, such radio communication can be established with only one airplane at a time, thereby avoiding the possibility of a mutilated code or other interference.

More specifically, it is further proposed to transmit the information, of airplane identity, airplane altitude and check-point identity, from such check-point location to a centralized dispatcher's office and to then retransmit information back to the pilot of such airplane as to his identity, the altitude at which he is flying and the check-point he is flying over, so that the pilot not only has the check-point specifically defined to him but also is informed of the fact that his identity as well as the altitude at which he is flying over a particular check-point has been transmitted to the dispatcher. If the pilot finds that his identity or altitude was improperly given he may call the dispatcher by radio-phone and correct the error thereover.

Another object of the present invention resides in the provision of means to prevent the transmission of the information above mentioned for

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a second time during a single flight over the check-point or other ground location.

Another object of the present invention resides in utilizing the check-point located apparatus for transmitting the answer-back message from the central office to the pilot of the airplane.

Another object of the present invention resides in the provision of means for preventing the check-point located apparatus from communicating with a second airplane until the complete answer-back information for a first airplane has been transmitted from the central office back to the pilot of such airplane.

Another object of the present invention resides in the provision of mechanism at the check-point ground location for determining which one of a plurality of airplanes flying at different altitudes over such location at the same time shall be first to communicate with the dispatcher's office through the medium of the check-point ground located apparatus.

Another object of the present invention resides in the provision of code creating, code repeating, and decoding mechanism for transmitting by code the aforementioned information between the airplane and the dispatcher's office.

Other objects, purposes and characteristic features of the present invention will in part be pointed out in the specification hereinafter and will in part be obvious from the accompanying drawings in which:

Figs. 1A and 1B show the airplane carried apparatus, the apparatus located at a check-point and a portion of the apparatus located at the dispatcher's office; and

Fig. 2 shows a time chart illustrating the sequence of operation of the various devices of the apparatus illustrated in Figs. 1A and 1B.

Structure.—Referring to Figs. 1A and 1B of the drawings, apparatus has been illustrated therein to show one embodiment of the present invention which apparatus is located at three different places, namely, on the airplane designated "Plane" by suitable legend, at the check-point location CPS, shown by dotted lines, and at the central office or dispatcher's office DO also shown by dotted lines. On the airplane, as illustrated, are shown a pilot's radio transmitter-receiver PIR which affords direct two-way radio communication between the pilot and the dispatcher's office or some operator under the dispatcher's jurisdiction, and in addition to this pilot's radio PIR there is provided an airplane receiver PR and an airplane transmitter PT for the purpose of automatically communicating

with the check-point radio transmitter CPT and the check-point radio receiver CPR. The radio communication between the pilot's radio PIR and the dispatcher's office DO may be established by tuning of the carrier or radio frequency only as is also true of the establishment of radio communication between the airplane transmitter PT and the check-point receiver CPR, but in order to establish a radio communication between the check-point transmitter CPT and the airplane receiver PR not only must the radio frequency be correct and conform with the tuning of the receiver PR but there must be superimposed upon this radio frequency a tone current which is capable of being received by the airplane receiver PR. In other words, proper tuning of the radio frequency and proper tuning of the tone current are both necessary to establish radio communication between the radio transmitting apparatus CPT located at a check-point and the airplane radio receiving apparatus PR located on the airplane.

Referring again to Fig. 1A, the pilot's radio PIR has been shown very conventionally and all the apparatus of this sending and receiving equipment is conventionally illustrated by the square PIR. In order to show how a code received by the receiver PR may be superimposed upon the message received by the pilot's receiving apparatus PIR, also located on the airplane, a contact 15 of the relay TR controlled by the airplane receiver PR has been illustrated, and this contact 15 may impose clicks on the earphones or pilot's headset PHS in accordance with the impulses of the code received. The pilot may of course speak to the dispatcher through the medium of the pilot's microphone PM. These clicks are preferably in the nature of distinctive tones which may be distinguished from other noises and these tones may be created by monitoring one radio frequency with another or one of the monitoring frequencies may be the tone modulation transmitted by the check-point transmitter CPT.

The airplane transmitter PT has been shown very conventionally and this transmitter transmits a radio communicating impulse toward the ground each time the contacts 16 associated with the code wheel PC3 are closed, it of course being assumed that the radio frequency employed for the pilot's radio PIR, for the airplane transmitter PT and the airplane receiver PR are all distinctively different. As shown, the code wheel PC3 is driven by a shaft 14 through the medium of the coding motor M3, and it has associated therewith two contacting or commutator rings PC1 and PC2. These commutator rings PC1 and PC2 are employed to control the motor M3 and the relay TRP through suitable circuits in a manner more fully described hereinafter.

Referring now to the airplane receiver PR, this radio receiver is tuned to be receptive to radio frequency within a particular radio frequency band assumed to be transmitted by the transmitter CPT but the relay TR which follows the radio energy received will only respond if the radio frequency received falls within this radio frequency band and if the received radio frequency is modulated to a tone corresponding to the particular altitude the airplane is flying at this time. This is accomplished by employing a contact 17 on an altimeter ALM which will select the proper tone for which the receiver is receptive for each altitude the airplane is flying. For instance, if the airplane is flying at an altitude of 2000 feet, as illustrated, this contact 17 will engage a contact 2 to tune the receiver PR to respond to a modulation selected for the 2000 foot altitude and similarly, if the airplane flies to a higher altitude this contact 17 will engage a stationary contact to tune the apparatus to a modulating frequency corresponding to such higher altitude. The stationary contacts have been numbered 2 to 9, inclusive, with the understanding that these contacts represent altitudes of 2000 to 9000 feet, respectively. This contactor 17 is preferably so constructed that it will always engage at least one of the stationary contacts 2–9 and will never engage more than one.

Referring now to the apparatus located at the check-point station CPS (see Fig. 1B), it will be observed that the radio transmitter CPT provided with an antenna AT1 is intended to communicate with the airplane receiver PR provided with an antenna AT2. Similarly, it will be readily seen, as conventionally indicated, that the airplane transmitter PT provided with an antenna AT3 is intended to communicate with the check-point receiver CPR provided with an antenna AT4.

The check-point transmitter CPT, conventionally illustrated by a rectangle, communicates a carrier frequency which is modulated to a suitable tone frequency corresponding to the tones 2 to 9 inclusive to which the airplane receiver PR will respond, one at a time, depending on the altitude the airplane is flying, that is, depending on the position assumed by the contact 17 of altimeter ALM. As conventionally illustrated, these tones 2 to 9, each inclusive, are generated by tone generators 2T to 9T, inclusive, conventionally illustrated as connected to the various contacts 2 to 9, inclusive, of the altitude scanner AS. This altitude scanner AS includes a rotatable contact arm 20. In practice, this rotatable contact arm 20 is rotating at all times except when radio communication between the check-point transmitter CPT and the airplane receiver PR and between the airplane transmitter PT and the check-point receiver CPR is established.

The contact 20 of this altitude scanner AS may be rotated by the scanning motor M1 through the medium of a clutch CM. In other words, the rotatable arm 20 which is driven by the motor M1 in the direction indicated by the arrow moves from contact to contact and in so doing superimposes on the radio frequency waves emitted by the transmitting antenna AT1, as by modulating the radio frequency, a tone current corresponding to the contact with which this rotary contact 20 is in engagement. In order to stop the rotatable arm 20 on a particular altitude contact, such as contact 2 for instance, a lock magnet LR has been provided, which by being energized causes the latch pawl 21 to engage one of the teeth of the latch wheel LW so as to prevent further rotation of the contact arm 20, this lock magnet LR simultaneously with such latching of the scanning shaft 22 also opens the contact 23 causing deenergization of the clutch magnet CM and preventing further rotation of this shaft 22 by the scanning motor M1. On this scanning shaft 22 is also provided a rotatable contact arm 24 which may engage similar contacts 2 to 9, inclusive, of an altitude detector AD, which contacts complete energizing circuits to altitude relays A2 to A9, inclusive. These altitude relays A2–A9 are constructed to be slow to pick up to an extent that these relays will not respond when the rotatable arm 20 is rotated by the motor M1 by reason of the fact that the energizing circuits

for these relays are not closed long enough to cause effective energization and picking up of these relays.

If, on the other hand, the scanning shaft 22 is stopped by the latch 21 engaging the latch wheel LW the circuit for a particular altitude relay, depending upon which contact is then engaged by the rotatable contact 24, will remain closed continuously resulting in the energization and picking up of this particular altitude relay, such as relay A2, for instance. Each of these altitude relays A2–A9 is provided with a front contact 25 and a back contact 26. The back contacts 26 of these altitude relays A2–A9 are all connected in series and normally close a circuit for a slow dropping relay AP, so that this slow dropping relay AP is normally energized and may through its front contact 27 normally energize its repeater relay APP which is only slightly slow dropping. At the check-point location CPS and associated with these altitude relays A2–A9 is provided rotary coding apparatus similar to the rotary coding apparatus located on the airplane and already described.

This check-point coding apparatus includes a coding motor M2 driving a shaft 30 on which there are mounted a commutator contact ring CPC and coding cams CPF, CP2, CP3, CP4, CP5, CP6, CP7, CP8 and CP9. Reduction gears (not shown) are of course interposed between each of the motors M1, M2 and M3 and their respective shafts 22, 30 and 14. The altitude repeating relay AP in addition to being provided with a contact 27, already mentioned, is also provided with a contact 28. The second repeater relay APP is provided with a stick contact 29 and a control contact 30. Each of the coding cams CPF and CP2–CP9 is provided with a roller operated contact similarly designated, but with the letter P omitted, that is, they are provided with contacts CF, C2, C3, C4, C5, C6, C7, C8 and C9. Each of these movable contacts is provided with a roller 31 which may be lifted by the cam teeth contained on these various coding cams to intermittently close these contacts in code fashion as the shaft is rotated. The check-point radio receiver CPR, including the necessary batteries or other suitable sources of energy, amplifying, rectifying and detecting tubes, and shown conventionally by a rectangle, controls two relays CR and SR. Each of these relays respond to amplified energy received by the antenna AT4, the relay CR being sufficiently quick acting to follow the impulses of the code received whereas the relay SR is somewhat slower acting and is further provided with a stick circuit including its stick contact 32 and the front contact 33 of the relay APP. This relay SR is also provided with a contact 33 which may control the lock relay LR. The relay CR is provided with contacts 34 for repeating the code received, by the receiver CPR from the airplane transmitter PT, to the central dispatcher's office DO provided the relay AP is then energized to hold its contact 28 closed.

As illustrated in the drawings the dispatcher's office DO is connected with the check-point apparatus and station CPS by line wires 37, 38 and 39. At this check-point station CPS there is also provided a relay K which is controlled from the dispatcher's office through the medium of the line wire 39.

The apparatus at the dispatcher's office, only a small portion of which has been illustrated conventionally, includes a code receiving relay OCR controlled over the line wire 37, a slow dropping

repeater relay ODC which assumes its energ position so long as a code is being received by code receiving relay OCR but which relay OD sufficiently slow dropping so as not to follow impulses of the code. This relay ODC is c trolled through a front contact 45 of the c receiving relay OCR and through the mediun its front contact 46 controls the relay K loca at the check-point station CPS. This dispat er's office code receiving relay OCR is also p vided with a front contact 47 which is inclu in the circuit of the line wire 38 and through medium of relay OCRP and its back contact controls the check-point radio transmitting paratus CPT so as to retransmit a code from check-point station to the airplane flying c that station and which is in communication w such station by having the scanning appara in correspondence with the altimeter indicat on that particular airplane. This code consist radio "off" periods created by the back contact of relay OCRP removing tone energy from transmitter. These "off" periods of the relay are indicated by the graph 62 in Fig. 2 of drawings.

Time chart.—Before the operation of the ap ratus illustrated in Figs. 1A and 1B can be c sidered to advantage step by step, it is believed sirable to have an understanding of the mean of the time chart illustrated in Fig. 2 of the dra ings. In Fig. 2 distances from left to right al horizontal lines reflect lapse of time, whereas various straight and notched graphs illustra represent the condition of the particular appa tus. For instance, the heavy line 50 illustra that the contact arm 20 of the altitude scan AS is in engagement with the stationary cont 9 whereas similar heavy lines 51, 52, 53, 54 a 55 represent engagements of stationary conta 8, 2, 3, 4 and 5 by this rotatable scanning c tact 20. The narrow line 49 indicates that scanner AS is in stationary locked condition d ing the time reflected by the length of this li The straight lines 56 and 57 illustrate periods energization of the coding motors M3 and M2 spectively. The short dashes such as 58 and signify that the coding contacts 16, CF and respectively are closed. The graphs 62, 63, 64, 66, 67, 76, 77, 78, 82, 86 and 87 shown on Fig of the drawings represent the conditions of ergization and positions assumed by the vari relays the reference numbers of which are as ciated with the graphs. A rise in the curves lustrated by these relays indicates that the re is operated from its deenergized to its energi position whereas a drop in this graph indica that the relay is moved from its energized to deenergized position. The degree of retard dropping of the relays is indicated by the ti required for a graph to drop to its lower po tion. In practice the relay TRPP is much m slow dropping than indicated, the chart not ing long enough to show the actual time of ab one-half minute required for this relay to dr With this understanding of the time chart t operation of the system may now be considered.

Operation.—Let us assume that the appara is in its normal condition with the lock mag LR deenergized and with the scanning motor rotating the contact arms 20 and 24. As t scanning motor M1 rotates these arms 20 a 24 all of the altitude relays A2–A9 will remain their deenergized positions and the check-po transmitting apparatus transmits success waves of modulated radio frequency, the ener

of which is derived through the back contact 43 of the relay OCRP. These pulses of radio carrier frequency energy have superimposed thereon, that is, are modulated by tone frequencies generated by the tone generators 2T to 9T inclusive, one at a time. That is, a tone pulse corresponding to tone generator 2T is first emitted by the antenna AT1 superimposed of course upon the carrier frequency, which is then followed by tone pulse 3 and then by tone pulse 4, and so on until all of the tone pulses 2 to 9 have been transmitted, after which this cycle is repeated.

Let us now assume that the airplane Plane (see Fig. 1A) gets within the range of the radio beam transmitted by the antenna AT1, it being understood that the radio frequency is such and the antenna so designed that this radiation of radio waves by the antenna AT1 is directed mainly upwardly through a limited angle of spread so that an airplane must be almost directly over the check-point in order to respond to the radiated energy. That is, in practice, the airplane remains in communication with the check-point apparatus only for about one-half minute during its flight over the check-point.

Let us now assume that the airplane Plane is flying at an altitude of 2000 feet and that its altimeter contact 17 is in engagement with stationary contact 2 of the altimeter ALM. Under this condition the airplane receiver PR is receptive only if radio waves of the proper frequency are emitted by the antenna AT1 and then only if they are modulated at the rate of modulation effected by tone generator 2T. On the next rotation of the scanning contact 20 when it reaches the stationary contact 2 of the altitude scanner AS, the energy transmitted by the transmitter CPT through the medium of the antenna AT1 to the receiver PR will cause the relay TR carried by the airplane Plane to pick up and by the closing of its front contact 60 closes an energizing circuit for the motor M3. This causes the motor M3 to operate and close a stick circuit for the stick relay TRP including the commutator contacts PC1 and stick contact 71. Rotation of the coding cam PC3 in a clockwise direction results in the closure of contact 46 of the airplane transmitter PT which results in the transmission of radio frequency energy impulses from the antenna AT3 to the antenna AT4 resulting in the picking up of the relays CR and SR. The picking up of the relay SR closes its front contact 33 thereby energizing the lock relay LR and causing the latch wheel LW to be held in its contact 2 position by the latch 21, in which position the rotary arm 20 still engages the stationary contact segment 2 of altitude scanner AS. Energization of the lock magnet LR by the opening of its contact 23 of course deenergizes the clutch magnet CM and removes the application of torque to the scanning shaft 22. It is thus seen that the check-point apparatus continues to transmit radio frequency energy modulated at the same rate as before from the transmitter CPT to the receiver PR on the airplane.

Referring now to Fig. 2 the picking up of the relays TR and TRPP on the airplane is indicated by the rise in graphs 62 and 63 whereas the picking up of the relays CR and SR and the energization of the lock magnet LR is indicated by the rise in graphs 64, 65 and 66, respectively. The relay CR will of course follow the code transmitted by the coding cam PC3 and this code consists of four impulses followed by three impulses followed by two impulses as indicated by

the humps on coding wheel PC3 and by the dashes 66 in Fig. 2 of the drawings. This code receiving relay CR then repeats these impulses 4—3—2 through the medium of its contact 36 by intermittent energization of the code receiving relay OCR located in the dispatcher's office DO. It will be seen that this code receiving relay OCR through the medium of its front contacts 47 will cause the received code to be retransmitted to the airplane by the intermittent energization of the relay OCRP and the intermittent opening of its back contact 46, which contact 46 feeds tone energy to the radio transmitter CPT. In other words, as indicated by graph 62 in Fig. 2 of the drawings the code transmitted by the airplane to the office is repeated back to the airplane by an "off" period for each "on" period of the ground located relays as shown by graphs 64, 75 and 62 representing the relays CR, OCR and OCRP in Fig. 2 of the drawings.

Let us now observe more specifically how the coding motor M3 on the airplane is energized and how it is deenergized after the coding cam PC3 has made one complete revolution. Referring to Fig. 1A the original picking up of the relay TR causes energy to be applied through the medium of its front contact 60 through a circuit including the motor M3 and the front contact 70 of the relay TRP. As soon as the coding shaft has turned through a small angle, and before the slow dropping relay TRP has had an opportunity to drop, the commutator contacts PC1 and PC2 are both closed thereby closing a stick circuit for the relay TRP including the contact PC1 and also including the stick contact 71 of the relay TRP. The motor M3 is now also energized through another or auxiliary circuit including the front contact 70 of the relay TRP and including the commutator contact PC2. This auxiliary circuit for the motor M3 is provided so as to cause continuous operation of the motor M3 in spite of intermittent deenergization and dropping of the relay TR.

The relay TRPP is energized each time that the relay TR is picked up and is also energized so long as the motor M3 is energized, so that this relay TRPP will assume its energized position as soon as the coding motor M3 is initiated into operation and will remain either continuously or intermittently energized until the relay TR is permanently deenergized. This relay TRPP is so slow dropping that it will not drop its contacts after complete deenergization of its windings until about one-half minute of time has elapsed. In practice this cannot be readily done by a relay of the ordinary construction and a special timing relay including a dash-pot or other suitable time delay means may be employed, if desired. When the motor M3 has operated the coding wheel PC3 through its entire revolution the stick circuit for the relay TRP is broken at the commutator contacts PC1 thereby causing deenergization of this relay TRP and causing deenergization of the motor M3 before the contacts PC1 reclose. The relay TRP will not again be picked up until the slow dropping relay TRPP has assumed its deenergized position, which requires about one-half minute, this by reason of the fact that the pick-up circuit for the relay TRP includes the back contacts 73 of the relay TRPP and 74 of the relay TR in series. In practice, as already pointed out, an airplane is not within the radiating range of the transmitter CPT at a check-point for more than about a half-minute and since the slow dropping relay TRPP

requires about a half-minute period to be operated to its deenergized position the airplane apparatus of a particular airplane can only get into communication once during a flight over a check-point radio transmitter.

Referring again to Fig. 2 of the drawings time has now elapsed as indicated by the nine dashes 58 representing the airplane identifying code and this code has not only been transmitted to the dispatcher's office as indicated by the jogged graph 64 signifying the operation of the relay CR and received at the dispatcher's office as illustrated by the jogged graphs 75 and 82 illustrating the operation of the code receiving relays OCR and OCRP located in the dispatcher's office and check-point respectively, but has also been retransmitted back to the airplane as indicated by the jogged graph 62, signifying the operation of the relay TR constituting part of the receiver PR located on the airplane Plane. This code is repeated into the pilot's earphone PHS through the medium of contact 15 of the relay TR.

Referring again to Fig. 2 it will be observed that altitude relay A2 has now been energized as indicated by the graph 87 and that the picking up of its contact 26 has caused deenergization of the relay AP. However, by reason of its slow dropping characteristic, as indicated by the shaded portion of the graph 77, this relay AP has not yet assumed its deenergized position. Dropping of the stick relay TRP has, however, taken place and this is indicated by shaded portion of the graph 78 of Fig. 2 of the drawings. In regard to the picking up of an altitude relay, such as the relay A2, this relay is slow to pick up, as conveniently indicated, and will not pick up during rotation of the contact arm 29 but will pick up if this contact arm stops on one of the stationary contact segments.

As thus far described the check-point located apparatus CPS has scanned the area directly above this location, and has found an airplane flying at the 2000 foot altitude, causing the scanner to stop on the contact segment 2 and resulting in the reception of radio waves by the airplane having a tone signifying the 2000 foot altitude superimposed thereon. This resulted in the lock magnet LR being magnetized which caused the apparatus on the airplane Plane to transmit a plane identifying code consisting of four impulses followed by three impulses, followed by two impulses and the coding apparatus on the airplane has completed its cycle and has again been brought to a stop,

As already pointed out the relay AP is very slow dropping, as indicated by the heavily shaded portion of line 77, and was held up throughout the entire transmission of the airplane identifying code to the dispatcher's office and back to the airplane. This relay AP has now reached its deenergized position as a result of which its back contact 27 has completed an energizing circuit through the motor M2 and including the front contact 30 of the stick relay APP. As soon as the motor M2 has operated the coding shaft 80 through a small angle a stick circuit for the relay APP is closed including the back contact 27 of the relay AP, the commutator contact CPC and the stick contact 29 of this relay APP. The motor M2 will now continue in operation until the coding shaft 80, driven through suitable gears (not shown), has completed one complete revolution at which point the stick circuit for the relay APP is broken at the commutator contact CPC. During this revolution of the coding shaft 80 the radio fix coding cam CPF, for identify the radio fix or check-point at which it is local will transmit code elements to identify t check-point, which consists of four pulses in present instance. This is followed by a series pulses identifying the altitude at which the a plane is flying, which in the present instance co sists of two pulses, will be transmitted by coding cam CP2 because the altitude relay now assumes the energized position and all the other altitude relays A3–A9 assume their energized positions.

It will be observed that the humps on the co ing cam CP2 do not overlap with the humps the coding cam CPF so that the four impul created by the cam CPF will be followed by t two impulses created by the coding cam CP2. T code will cause intermittent picking up and dro ping of the code following relay OCR in the d patcher's office DO through a circuit which m be traced from the positive terminal of a sou of current through back contact 28 of the rel AP and through the contact CF controlled the coding cam CPF and through a multi branch circuit also including this back conta 28 of relay AP and front contact 25 of relay and further including the contact C2 of the co ing cam CP2 and from there on these two multi circuits converge into one circuit including t line wires 37 and the code following relay O located in the dispatcher's office. This code co sisting of a group of four impulses identifyi the radio fix, followed by a group of two impul identifying the altitude at which the airplane flying, is indicated by the dashes 59 in Fig. 2 the drawings. It will be observed that these co impulses result in corresponding picking up a dropping of the relays OCR and OCRP as sho by the graphs 75 and 82 of Fig. 2 and is also i dicated by corresponding "off" periods in the e ergizing circuit for the relay TR as indicated the graph 62 in Fig. 2 of the drawings.

Referring to Fig. 1B it will be observed th the code transmitted from the airplane to the d patcher's office and consisting of an airplane ide tification code cannot overlap or interfere wi the code transmitted by the coding cams C and CP2 because the first of these codes is trar mitted through a circuit including the front co tact 28 of the relay AP whereas the second me tioned code is transmitted through a circuit i cluding the contact 28 in its deenergized po tion.

Referring now to the graph 86 in Fig. 2 of t drawings, this graph shows that the relay O was picked up in response to the first code i pulse transmitted to the dispatcher's office manifested by the relay OCR and was not dropp until the last element of the complete code h been transmitted, and that the relay K controll by this relay ODC repeats this same operation the check-point location. This is shown in Fig by the graph 87. By referring to Fig. 2 it will observed that the apparatus at the check-poi and on the airplane is not returned to its nc mal condition immediately after the entire co has been retransmitted to the airplane ev though the apparatus located in the dispatche office is. This is due to the fact that the pa ticular altitude code which was assumed to ha been transmitted was a two-impulse code sig fying an altitude of 2000 feet and for this reas the coding shaft 80 had not completed its rot tion and this idle rotation of the shaft 80 is inc

cated by the dots 66 associated with the dashes 39 in Fig. 2 of the drawings.

Upon completion of the rotation of one revolution of the shaft 30 the stick circuit for the relay APP is broken and this relay APP assumes its deenergized position as indicated by the drop in the graph 88 in Fig. 2 of the drawings. Dropping of the relay APP results in the interruption of the stick circuit for the lower winding of the relay SR. Relay SR then assumes its deenergized position as indicated by the shaded part of graph 86 in Fig. 2 of the drawings. The dropping of the relay SR is followed by the dropping of the lock magnet LR and in the restarting of the rotation of the scanning shaft 22.

As soon as the scanning contact 20 leaves the fixed contact 2 (end of graph 60, Fig. 2) radio transmission with the proper tone superimposed thereon from the check-point location to the airplane is discontinued. This causes deenergization of the relay TR on the airplane as indicated by the shaded portion of the graph 62 in Fig. 2 of the drawings. For obvious reasons the altitude relay A2 will also be deenergized because its circuit is broken at the rotary contact 24 of the scanning mechanism, AD, and this is shown by the shaded portion of graph 67. As soon as the altitude relay A2 assumes its deenergized position an energizing circuit for the relay AP is closed at back contact 26 of the altitude relay A2 thereby causing the relay AP to be reenergized and picked up as indicated by the rise in graph 77 near the right-hand portion of Fig. 2 of the drawings. The picking up of the relay AP results in the closure of an energizing circuit for the relay APP as indicated by the rise in the graph 86 near the right-hand end in Fig. 2. Deenergization of the relay TR as indicated by the shaded portion of the graph 62 in Fig. 2 of the drawings results in the total deenergization of the winding of the repeater relay TRPP and after a lapse of time, as conventionally indicated by the shaded portion of graph 68 in Fig. 2 of the drawings, this relay TRPP assumes its fully retracted position, at which point in the operation of the system the relay TRP is reenergized to its normal position as indicated by the rise in the graph 78 near the right-hand end of Fig. 2 of the drawings.

The apparatus has thus been operated through one complete cycle of operation which was evidenced by the stopping of the scanning mechanism, by the rotation of the coding mechanism on the airplane through one complete revolution, followed by a complete revolution of operation of the coding shaft 30 and associated mechanism located on the ground at the check-point or radio fix under consideration, by the transmission of an answer-back message and in the restarting of the scanning mechanism into operation.

Although it has not been shown specifically herein how the information transmitted to the dispatcher's office is to be used, that is, whether it is to control special apparatus or indicators or whether the code is to be audibly interpreted, it should be understood that the codes may be decoded by decoding apparatus DC including a circuit closed in response to the proper code to momentarily energize a relay. This relay may then be used to display a visual indication, produce an audible signal or cancel a displayed airplane flight indication, of systems such as disclosed in the prior applications of Wight, Ser. No. 432,121, filed February 24, 1942, now Patent No. 2,344,759, granted March 21, 1944, or Wight and Field, Ser. No. 454,453, filed August 11, 1942, now Patent No. 2,344,760, granted March 21, 1944.

The advantage in repeating the information transmitted to the dispatcher's office back to the airplane resides in informing the pilot automatically and definitely that he is passing over a particular radio fix. It also enables the pilot to recheck the information transmitted to the dispatcher's office as to his identity and the altitude he is then flying.

The same operation just described for an airplane assumed to pass over a particular ground station illustrated at an assumed altitude of 2000 feet will occur if some other airplane passes over this ground station at any one of the operating altitudes. It will sometimes happen, particularly at the approach to airports or other ground locations where there is dense traffic, that a plurality of airplanes flying at different altitudes will pass over the same ground station at exactly or substantially the same time. In the system of this invention, when this occurs, each of these airplanes will make its report when the scanner device assumes the position corresponding with the altitude at which that airplane is flying. Consequently, each one of the plurality of airplanes passing over the ground station at about the same time will report their passage one at a time in turn and in a sequence determined by their respective altitudes. In this connection, it is contemplated that the speed of the scanning operation and the time an airplane will be within the influence of a ground station transmitting equipment will be chosen so that the complete scanning and report operation for the number of airplanes likely to pass the ground station at exactly the same time will occur in less than the time these planes will be within the influence of the ground station equipment. It may be expected that a small number of airplanes are likely to be exactly over each other while passing over the ground station at different altitudes; and when and where the airplanes pass over the ground station in succession, there is ample time for the passage of each of these airplanes to be reported before the next airplane gets out of the control zone above the ground station.

The applicants have thus shown one embodiment of the present invention which illustrates apparatus for transmitting by radio a code from only one of a plurality of airplanes flying over a check-point at the same time providing that these airplanes fly at different altitudes. This apparatus is capable of transmitting such code through apparatus located at the radio fix or check-point location through line wires, resulting in the retransmission of the same code back through apparatus located at the check-point and to apparatus located on the airplane. The apparatus also includes means for having this answer-back code applied to the pilot's regular receiving apparatus and head-set which is used for carrying on direct radio communication between the pilot and the dispatcher. Although the apparatus disclosed employs a plurality of line wires between the check-point location and the dispatcher's office it should be understood that this particular construction has been resorted to to show one manner in which the code may be transmitted to the dispatcher's office and through the medium of which an answer-back code may be transmitted, but it should be understood that this transmission may be carried on through the medium of a single line wire and suitable code re-

sponsive, code repeating, and decoding apparatus and that if desired this may be accomplished through the medium of a radio communication system. It should also be understood that if desired the answer-back code may be transmitted directly to the pilot without going through the radio transmitting apparatus located at the check-point or radio fix location.

It should also be understood that, if desired, instead of having the airplane receiver PR rendered responsive only to radio transmission of a particular radio frequency modulated to a particular tone that this response may be through the medium of particular radio frequencies alone and irrespective of tone current modulation. The tuning of the receiving apparatus PR would be accomplished in this case through the medium of a contact similar to the contact 17 on the altimeter. In other words, instead of using one radio carrier frequency and a plurality of tone frequencies a plurality of radio carrier frequencies without having a tone frequency superimposed thereon may be employed, if desired. Since the conventional showing would be the same no additional drawings are deemed necessary.

The applicants have thus shown and described one particular embodiment and slight variations of their invention and one manner in which their invention may be employed, and have disclosed this invention in a more or less conventional manner. It is therefore desired to be understood that this has been done because radio communicating apparatus is well-known in the art and detailed circuits and apparatus including amplifier, rectifier and detector tubes are so well known in the art that specific disclosure thereof is considered and believed unnecessary and it should be understood that the particular apparatus shown and described has been selected to show the nature of the invention and has not been illustrated to show the exact construction preferably employed in practicing the invention and it should be understood that various changes, modifications and additions may be made in practising the invention so long as these changes come within the scope of the following claims.

What is claimed as new is:

1. In combination with ground station located radio transmitting apparatus, of means operatively coupled to said radio transmitting apparatus for successively emitting radio beams characterizing different altitudes, airplane carried radio receiving apparatus having tuned means adjusted to respond to such radio beams one at a time, and altitude responsive means operatively coupled to said airplane carried radio receiving apparatus for adjusting said tuning means of said radio receiving apparatus to respond only to a radio beam characterizing the altitude such airplane is flying at at that time.

2. In combination with ground station located radio transmitting apparatus, of means operatively coupled to said radio transmitting apparatus for successively emitting radio beams characterizing different altitudes, airplane carried radio receiving apparatus having tuned means adjusted to respond to such radio beams one at a time, altitude responsive means operatively coupled to said airplane carried radio receiving apparatus for adjusting said tuning means of said radio receiving apparatus to respond only to a radio beam characterizing the altitude such airplane is flying at at that time, and means to cause said radio transmitting apparatus to continue for a limited time to emit a radio beam characterizing a particular altitude if the airplane carried radio receiving apparatus has been adjusted by said altitude responsive means to such altitude adjustment and has responded to the initial radio beam characterizing such altitude.

3. In combination, a central office, a ground station, an airplane carried apparatus, code creating means included in such airplane carried apparatus for transmitting by radio a code identifying such airplane, code creating means at such ground station having its operation governed by transmission of said airplane identifying code for generating a code identifying such ground station, communicating means controlled by said code creating means for transmitting both of such codes over line wires to said central office in non-overlapping succession, and radio communicating means for retransmitting over a distinctive channel both of said codes from said central office to said airplane carried apparatus.

4. The combination of interrelated radio transmitting apparatus at a check point ground station and radio receiving apparatus carried by an airplane, interrelated radio transmitting apparatus on said airplane and radio receiving apparatus at said ground station, of means including the radio transmitting apparatus at said ground station for successively emitting radio beams characterizing different altitudes, airplane carried altitude responsive means for adjusting the airplane carried radio receiving apparatus to render it responsive to a radio beam emitted by the ground station located radio transmitting apparatus characteristic of the altitude the airplane is flying at at that time as manifested by such altitude responsive means, means responsive to the reception of a radio beam initiated by said airplane carried radio receiving apparatus and emitted by the airplane carried radio transmitting apparatus and received by the radio receiving apparatus at said ground station for causing the radio transmitting apparatus at such ground station to continue to transmit the last transmitted radio beam for a predetermined period of time, and means on said airplane for transmitting information to such ground station identifying said airplane through the medium of the radio transmitting apparatus on said airplane and the radio receiving apparatus at said ground station during said period of time.

5. The combination of interrelated radio transmitting apparatus at a check point ground station and radio receiving apparatus carried by an airplane, interrelated radio transmitting apparatus on said airplane and radio receiving apparatus at said ground station, of means including the radio transmitting apparatus at said ground station for successively emitting radio beams characterizing different altitudes, airplane carried altitude responsive means for adjusting the airplane carried radio receiving apparatus to render it responsive to a radio beam emitted by the ground station located radio transmitting apparatus characteristic of the altitude the airplane is flying at at that time as manifested by said altitude responsive means, means responsive to the reception of a radio beam initiated by said airplane carried radio receiving apparatus emitted by the airplane carried radio transmitting apparatus and received by the radio receiving apparatus at said ground station for causing the radio transmitting apparatus at such ground station to continue to transmit the last transmitted

o beam for a predetermined period of time, ns on said airplane for transmitting infor- ion to such ground station identifying said lane through the medium of the radio trans- ing apparatus on said airplane and the radio iving apparatus at said ground station dur- such predetermined time, and means at said ind station for through the medium of said ind station located radio transmitting appa- s and said airplane carried radio receiving aratus transmitting information identifying ground station.

In combination, a ground station located o transmitting apparatus, a ground station ted radio receiving apparatus, airplane car- radio receiving apparatus and airplane ied radio transmitting apparatus, of means ratively associated with said ground station ted radio transmitting apparatus for caus- such apparatus to successively emit space lations each characteristic of a different alti- e, airplane carried means including said air- ne carried receiving apparatus for causing the ratively associated airplane carried space lation transmitting apparatus to transmit a ce radiation when the operatively associated plane carried radio receiving apparatus re- es a space radiation characteristic of the alti- e the airplane is then flying at, and ground ted code communicating apparatus for trans- ting to a distant point a code characteristic that altitude in response to the reception of ce radiation by the ground located radio re- ing apparatus from such airplane carried io transmitting apparatus.

. In a system for automatically reporting the sage and identity of airplanes flying over a und station; equipment on each airplane in- ding radio transmitting means, a code send- device and means coupling them together so to when rendered effective transmit a radio le signal identifying that airplane; receiving paratus at a ground station responsive to such dio code signal for when received communicat- that code signal to a distant control office; d means partly at said ground station and tly on each of a plurality of passing airplanes d including the transmitting means on such rality of airplanes and said receiving appara- for rendering said equipments on said air- nes effective only one at a time in a sequence ed by the respective altitudes of said airplanes that time.

3. In a system of the character described for porting the passage of airplanes over a ground tion; transmitting means at the ground sta- n normally radiating in a limited area over d station a carrier frequency having distinc- e tone modulations relating to different alti- ies automatically applied thereto successively e at a time; means on an airplane including a dio receiver, a radio transmitter and an altim- r means for transmitting on a different fre- ency a reporting signal for a limited time only the modulation of the carrier frequency radi- ed by said ground station transmitting means rresponds with the altitude at which that air- ane is then flying as manifested by said altim- r means; and means including radio receiv- g equipment at the ground station responsive said reporting signal and including communi- ting apparatus for automatically communicat- g to a distant control office an indication mani- sting the passage of such airplane at such itude.

9. In a system for automatically reporting to a distant control office the passage of airplanes over a ground station, transmitting means at the ground station normally operating to radiate upwardly throughout a zone of limited extent a plurality of radio beams of distinctive character one at a time in succession to designate different altitudes, radio receiving apparatus on each airplane automatically adjusted to be responsive to only one of said radio beams having the character corresponding with the altitude at which that airplane is then flying; a radio frequency transmitter on the airplane having its operation initiated by the response of said receiving apparatus for radiating for a limited time a reporting signal, and means at the ground station responsive to said reporting signal, whereby a plurality of airplanes that may be passing over a ground station at different altitudes will report their passage one at a time as the ground station transmitting means successively creates the radio beams of the distinctive characters corresponding with the respective altitudes at which these airplanes are flying.

10. A system for reporting the identity and passage of airplanes over a ground station comprising, transmitting means at the ground station for radiating over an area of limited extent above the ground station a plurality of distinctive radio beams relating to different altitudes one at a time in succession, a radio receiver on each airplane for operating an electro-responsive device, means including an altimeter for controlling said receiver to cause operation of the electro-responsive device only in response to one distinctive radio beam corresponding with the altitude at which the airplane is then flying, means on each airplane including a radio transmitter and a coding device having its operation initiated by said electro-responsive device for transmitting for a limited time a reporting signal including an airplane identifying code, and means at said ground station for receiving said reporting signal and transmitting it to a distant control office.

11. In a system for automatically reporting at a distant point the passage of airplanes over a ground station, radio transmitting means at the ground station including a scanner device normally radiating upwardly over a limited area a plurality of initiating radio beams of distinctive characters relating to different altitudes one at a time in succession, a normally inactive radio transmitter on each airplane operable when set into operation to send automatically a reporting signal for a limited time, means on the airplane for initiating operation of said transmitter in response to the reception of an initiating radio beam having the character corresponding with the altitude at which the airplane is then flying, and means at the ground station responsive to said reporting signals for transmitting to a distant point a code signal conforming with the position of the scanner device at the time a reporting signal is received, whereby the altitude of each passing airplane is communicated to the distant control point.

12. In an automatic airplane reporting system of the character described, transmitting apparatus at a ground station including a rotary scanner normally operating to radiate upwardly over a zone of limited area a carrier wave modulated with a plurality of distinctive tones one at a time as the scanner rotates, means on an airplane including an altitude detecting device for sending a radio signal on a different frequency

only if said carrier wave is then modulated with a tone corresponding with the altitude at which the airplane is then flying; and means at the ground station responsive to said radio signal for stopping operation of the rotary scanner for a limited time.

13. In a system for automatically reporting the passage of airplanes over a ground station, radio transmitting means at the ground station for radiating upwardly over a limited area a radio carrier wave, scanning means for automatically applying distinctive tone modulations to said carrier wave for different altitudes one at a time in rapid succession, means on each airplane including a normally inactive radio transmitter operating at a different frequency from said carrier wave and responsive to the reception of the particular modulation of said carrier wave corresponding with the altitude at which that airplane is then flying for sending a reporting signal to the ground station, means controlled by the reception of said reported signal at the ground station for discontinuing for a limited time operation of said scanning means and the change in the modulation of the carrier wave, and means responsive to said reporting signal for communicating to a distant control office a code corresponding with the modulation existing upon reception of a reporting signal and representing the altitude at which the airplane giving such reporting signal passed over the ground station.

14. A system for automatically reporting the passage of airplanes over a ground station comprising, transmitting means at the ground station normally operating to radiate upwardly over a zone of limited area each one of a plurality of radio beams of distinctive character in succession relating to different operating altitudes for airplanes passing the ground station, means on each airplane set into operation by the reception of a radio beam having the character corresponding with the altitude at which that airplane is then flying for transmitting a radio reporting signal to the ground station, a coder at said ground station operable to transmit a code representing the altitude of the airplane causing such reporting signal, and means associated with said ground station and responsive to said reporting signal for automatically initiating operation of said coder and for governing said transmitting means to prevent a change in the character of the radio beam being radiated until after said coder operation has been completed.

15. A system for reporting to a distant control office the passage of airplanes over a ground station and their altitudes comprising, transmitting means at the ground station including a scanner device for normally radiating in succession each one of a plurality of radio beams of a distinctive character, means on the airplane acting automatically to send a radio reporting signal only when the character of the radio beam being radiated in accordance with the position of said scanner device corresponds with the altitude at which said airplane is then flying, a coding device at the ground station operable to send any one of a plurality of distinctive altitude codes to a distant control office, and means at the ground station responsive to the reception of said reporting signal for temporarily stopping the operation of said scanner device and for initiating operation of said coding device to send to the distant control office an altitude code corresponding with the existing position of the scanner device.

16. In a system for reporting the passage of airplanes over ground stations, radio transmitting means on each airplane including a device for creating a code signal distinctively identifying that airplane, a code sending device for each ground station operable to create a code characteristic of that station, and means partly on the airplanes and partly associated with said ground stations and responsive to the reception of an airplane identifying code at a ground station due to the passage of an airplane by said station for repeating that code over line wires to a distant control office and for thereafter initiating operation of the code sending device at that ground station to send to said control office the identifying code for that ground station.

17. In a system of the character described for automatically reporting the passage of airplanes over a ground fix, radio transmitting means at the ground station normally acting to radiate upwardly over a zone of limited area an initiating space radiation, an airplane carried radio receiver responsive to said initiating space radiation when such airplane flies over the ground fix, means on each airplane including a radio transmitter operating at a different frequency from said space radiation for sending a reporting signal of limited duration to the ground station, said means including means for causing the radio receiving apparatus on the airplane which is responsive to said initiating space radiation to initiate operation of said transmitter, and means at the ground station including a coding device and automatically set into operation by the reception of a reporting signal for sending to a distant control point a series of code pulses identifying the ground station and also interrupting the operation of said ground station transmitting means in accordance with such code, whereby the airplane receives a code identifying the ground station at the same time the passage of such airplane is automatically reported to a distant control office.

18. In combination, airplane carried radio transmitting apparatus, ground station located radio receiving apparatus, airplane carried means including said radio transmitting apparatus for transmitting to said ground station located radio receiving apparatus information disclosing the identity of the airplane carrying such transmitting apparatus, and radio transmitting apparatus at said ground station and radio receiving apparatus located on such airplane for retransmitting to such airplane said information as received at said ground station and also transmitting additional information as to the identity of such ground station to such airplane.

19. In combination, a ground station located radio transmitting apparatus, a ground located radio receiving apparatus, airplane carried radio receiving apparatus, airplane carried radio transmitting apparatus, means including a rotatable shaft normally rotated and operably associated with said ground station located radio transmitting apparatus to cause such apparatus to successively emit space radiations of different characters one at a time each characteristic of a flying altitude for passing airplanes, an electro-magnet for at times holding said shaft at stop, means governed by said ground located radio receiving apparatus for controlling said electro-magnet to bring said shaft to a stop and to thereby continue temporarily the then transmitted space radiation characteristic, means on the airplane governed by said airplane carried receiving apparatus and

rendering said airplane carried transmitting apparatus active when a space radiation characteristic of the existing altitude of said airplane is received, means operably associated with said ground station located radio transmitting apparatus for causing the temporarily continued space radiation to be coded to a code identifying that ground station, and airplane carried code transmitting means for transmitting additional information concerning said airplane through the medium of said airplane carried radio transmitting apparatus transmitted space radiation when said airplane carried radio transmitting apparatus is rendered active.

20. In combination, a ground station located radio transmitting apparatus, a ground located radio receiving apparatus, airplane carried radio receiving apparatus and airplane carried radio transmitting apparatus, of scanning means operatively associated with said ground station located radio transmitting apparatus for causing such apparatus to successively emit space radiations each characteristic of a different operating altitude for passing airplanes, airplane carried means for causing the associated airplane carried radio transmitting apparatus to transmit a radio signal when the associated radio receiving apparatus receives a space radiation from said ground located radio transmitting apparatus which is characteristic of the altitude of that airplane, and ground located code communicating apparatus governed by said scanning means for transmitting to a distant point a code characteristic not only of the altitude of the airplane which caused the transmission of said radio signal but also transmitting thereto by code the identity of the ground radio transmitting and receiving apparatus.

21. In combination, a ground located station, normally inactive code creating means at said ground located station which if initiated creates a multiple element code characteristic of the identity of said ground located station, radio transmitting and radio receiving apparatus at said ground located station, airplane carried radio transmitting apparatus for initiating said ground located station code creating means, airplane carried altimeter means automatically controlling said airplane carried radio transmitting apparatus in a manner dependent on the altitude at which the airplane is then flying, airplane carried radio receiving apparatus, and means controlled by the transmission of space radiation emitted by said airplane carried radio transmitting apparatus and received by said ground located radio receiving apparatus for initiating said code creating means to thereby cause said ground located radio transmitting apparatus to transmit such multiple element radio code through the medium of said ground located radio transmitting apparatus to said airplane carried radio receiving apparatus.

22. In combination, a ground located station, a central office, normally inactive code creating means at said ground located station which if initiated creates a multiple element code characteristic of the identity of said ground located station, radio receiving apparatus at said ground located station, airplane carried radio transmitting apparatus, means on the airplane dependent for its operation on the altitude at which such airplane is flying for initiating said airplane carried radio transmitting apparatus, and means controlled by the transmission of space radiation emitted by said airplane carried radio transmitting apparatus and received by said ground located radio receiving apparatus for initiating said code creating means, and means for transmitting such multiple element code to said central office.

23. In combination, a ground located station, a rotatable shaft at said ground located station, code creating means at said ground located station which is normally inactive and which if rendered active is capable of transmitting any one of a plurality of distinctive codes each depending for its character on the rotated position then assumed by said shaft, and means including airplane carried radio transmitting apparatus and radio receiving apparatus at said ground located station for rendering said code creating means active with said shaft assuming a particular rotated position corresponding with the altitude at which said airplane is then flying to thereby cause the transmission of a particular distinctive code.

24. In combination; a ground located station; a rotatable shaft at said ground located station; code creating means and radio transmitting means at said ground located station which is normally inactive and which if rendered active is capable of transmitting any one of a plurality of distinctive radio codes each characterizing a different altitude and depending for its character on the rotated position then assumed by said shaft; and means including an airplane carried altimeter, an airplane carried radio transmitting apparatus and radio receiving apparatus at said ground located station for rendering said code creating means active when said shaft assumes a particular rotated position characteristic of the altitude then manifested by said altimeter to cause said code creating means to transmit a code characteristic of the altitude the airplane is then flying at.

25. A system for automatically reporting to a distant control office the passage of a plurality of airplanes flying at different altitudes over a ground station comprising, radio receiving means and radio transmitting means at said station, an airplane carried radio transmitter operable when set into operation to at times send a reporting signal to the radio receiving means at said ground station, airplane carried control means including an airplane carried radio receiver and an airplane carried altimeter means for initiating operation of said transmitter dependent upon the altitude at which the airplane is then flying and dependent upon radio communication received by said airplane carried radio receiver from said ground station transmitting means, and means including said radio transmitting means at the ground station and controlled in part through the medium of said ground station located radio receiving means for actuating said control means on each of a plurality of airplanes passing over the ground station one at a time in succession in accordance with the respective altitudes at which these airplanes are flying.

26. In a system for automatically reporting the passage of airplanes over a ground station, ground located radio transmitting and receiving apparatus, airplane carried radio transmitting and receiving apparatus, scanning means operatively associated with said ground located apparatus for causing space radiations to be successively emitted by said transmitting apparatus, each such radiation being characteristic of a particular altitude employed by passing airplanes, and the successive radiations being for the different altitudes in successive rotation, airplane carried

means governed by its associated receiving apparatus in response to the reception of a space radiation characteristic of the altitude in which the plane is then travelling for causing the associated transmitting apparatus to transmit a radio signal characteristic of the identity of the plane, means at the ground station governed by the associated receiving apparatus for stopping operation of said scanning means during transmission from said plane, communication means associated with said ground station and governed in part by said associated receiving apparatus and in part by said scanning means for transmitting to a distant station a code characteristic of the identity of said plane, the altitude of said plane and the identity of said ground station, and means on said plane governed by the associated apparatus for preventing a subsequent operation of the transmitting apparatus in response to the reception of a radiation characteristic of its altitude for a predetermined limited time.

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