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(54) **SUB-ORBITAL, HIGH ALTITUDE COMMUNICATIONS SYSTEM**

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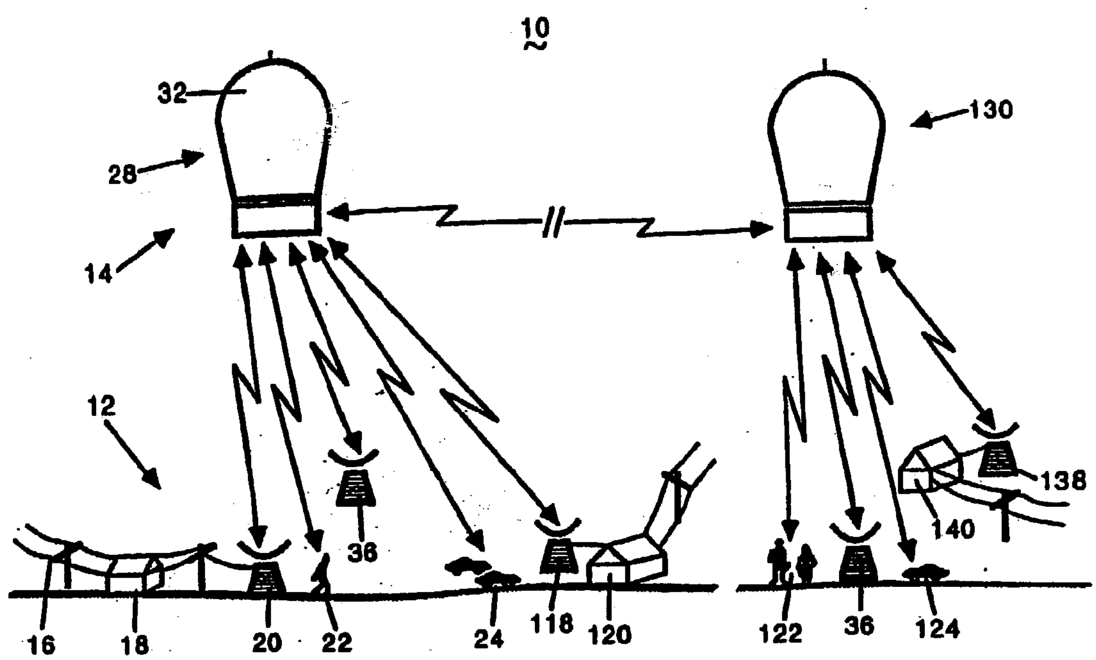
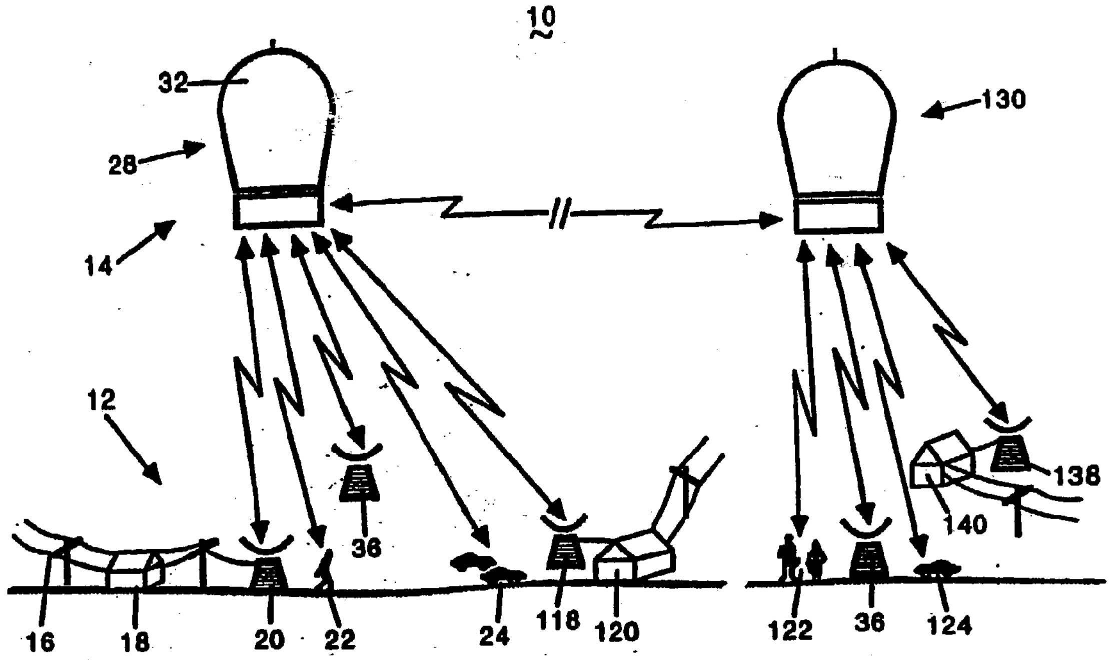
(57) **ABSTRACT**

A sub-orbital, high altitude communications system that has at least two ground stations and at least one high altitude relay station. Each of the ground stations includes apparatus for sending and receiving telecommunications signals. The relay stations include apparatus for receiving and sending telecommunications signals from and to the ground stations and from and to other relay stations. Apparatus is provided for controlling the lateral and vertical movement of the relay stations so that a predetermined altitude and location of each of the relay stations can be achieved and maintained. Apparatus is provided for retrieving relay stations so that they can be serviced for reuse.




10
32
28
14
130
12
36
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16
18
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22
24
118
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122
36
124

FIG. 1

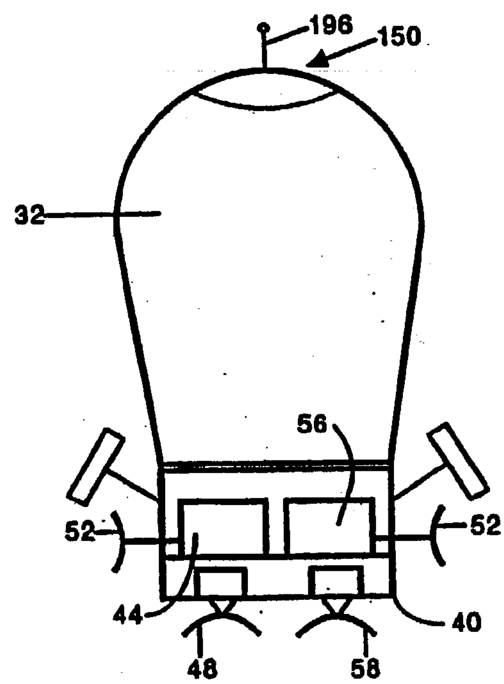
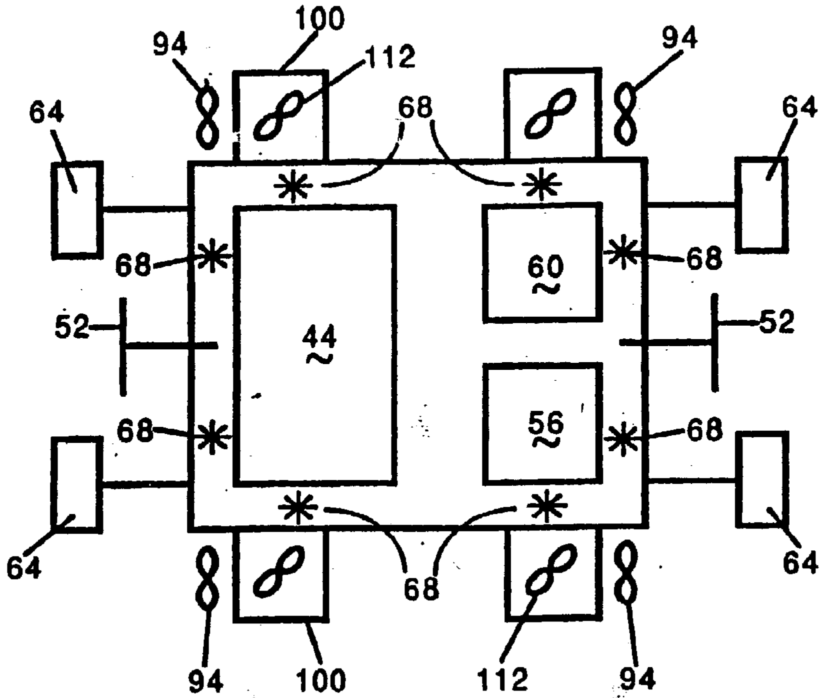

196
150
32
56
52
52
44
40
48
58

FIG. 2


100
94
112
94
68
64
64
68
68
60
52
44
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68
56
68
64
64
68
94
100
112
94

FIG. 3

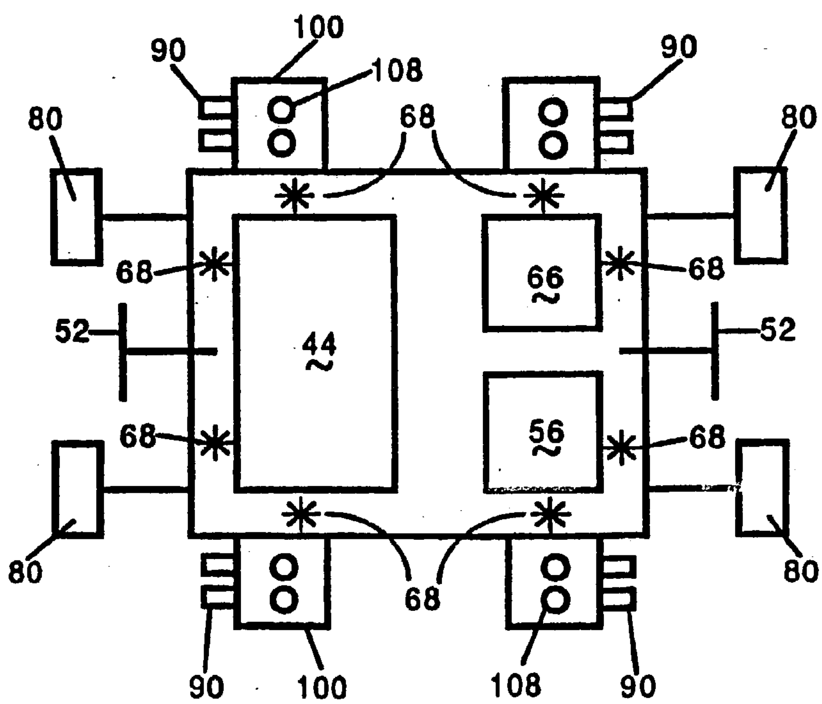
100
90
108
90
68
80
80
68
66
68
52
44
52
68
56
68
80
80
68
90
100
108
90

FIG. 4

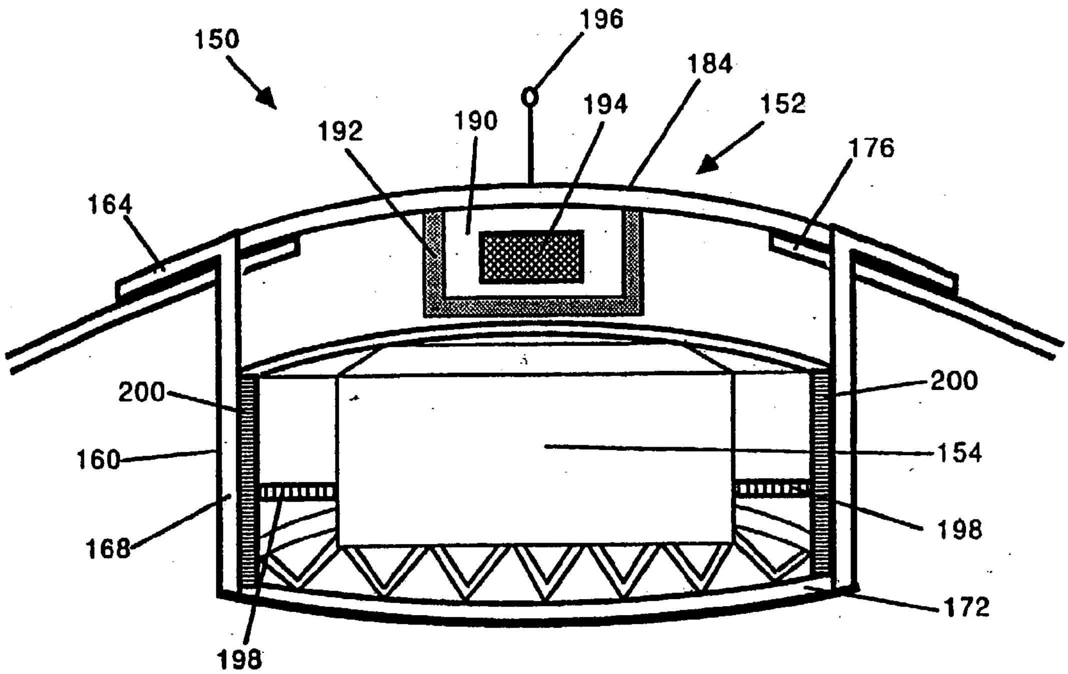
150
196
184
152
194
190
192
176
164
200
200
160
154
198
168
172
198

FIG. 5

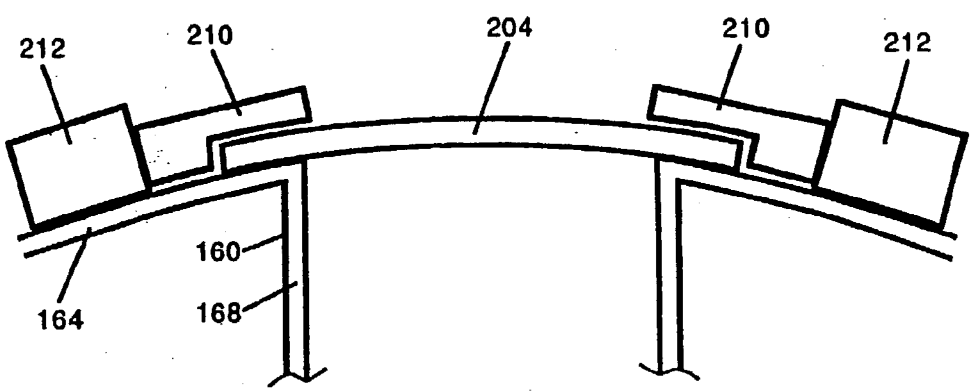
212
210
204
210
212
160
164
168

FIG. 6

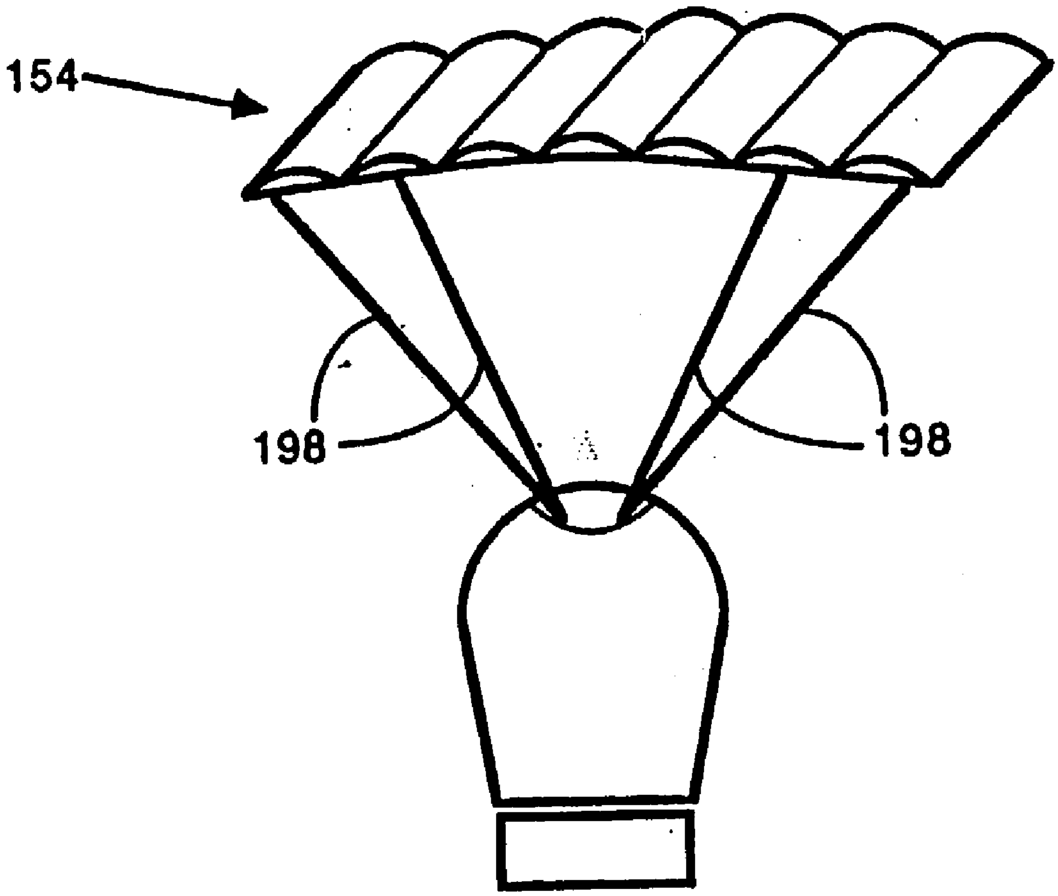

FIG. 7

SUB-ORBITAL, HIGH ALTITUDE COMMUNICATIONS SYSTEM

RELATED APPLICATIONS

[0001] This application claims under 35 U.S.C. §120 the benefit of the filing date of prior U.S. application Ser. No. 08/929,752, now pending, which in turn claims under 35 U.S.C. §120 the benefit of the filing date of prior U.S. application Ser. No. 08/661,836, now abandoned, which in turn claims under 35 U.S.C. §120 the benefit of the filing date of U.S. application Ser. No. 08/100,037, now abandoned.

FIELD OF THE INVENTION

[0002] This invention relates to a communication system, and more particularly to a communications system that is operative at the sub-orbital level yet well above any system which is connected to the ground.

BACKGROUND OF THE INVENTION

[0003] Long distance telecommunications systems currently use space satellite transmission or ground based systems that rely upon towers, tall buildings, tethered balloons and the like.

[0004] Satellite systems have been used for many years with a high degree of reliability. They are particularly advantageous since due to their altitude one satellite can send and receive signals from an area encompassing hundreds of thousands of square miles. However, satellites are expensive to manufacture and are expensive to launch and place in position. Further, because of the costs associated with their manufacture and launch, and the great difficulty in servicing them, extraordinary care must be taken to assure their reliability. Notwithstanding this, when a satellite fails, as assuredly they all—must do, either electronically, or by degradation of orbit, substantial expense is incurred in replacing it and the equipment it carries.

[0005] Ground based systems do not have the high costs that are associated with satellite systems. However, because they are low, a particular relay station may only be able to send and receive signals over a few hundred square miles. Thus, to cover a large area, many such relay stations must be provided. Further, ground based systems suffer from line-of-sight problems in that mountains, tall trees, tall buildings and the like interfere with the propagation of telecommunications signals. Still further, it may not be possible to install a telecommunications relay station at a particular site where one is needed due to geographic or political factors, or merely because of the inability to obtain permission from a land owner or government.

[0006] To some extent these problems are alleviated by using tethered balloons. However, tethered balloons are subject to the atmospheric conditions that exist at lower altitudes and are likely to be damaged as they are subject to weather conditions thereby requiring frequent replacement. Also, if they are flown at altitudes that enable them to relay telecommunications signals over a large enough area to make them economically feasible, the tethers become hazardous to aircraft.

[0007] It would be advantageous to provide a stable, long duration, telecommunications system which is based on a sub-orbital, high altitude device which has the ability to receive telecommunication signals from a ground station and relay them to another similar device or to a further ground station.

[0008] If the relay stations were made of high altitude, long duration lighter than air devices whose location could be controlled so as to be over a particular location on the earth, a means will have been created for providing relatively low cost telecommunication service such as a telephone service for remote areas without incurring the expense associated with satellite based communication systems, and without the disadvantages of a ground system or a tethered balloon system.

SUMMARY OF THE INVENTION

[0009] Accordingly, with the foregoing in mind the invention relates generally to a telecommunications system that comprises at least two ground stations. Each of the ground stations includes means for sending and means for receiving telecommunication signals. At least one relay station is provided. The relay station includes means for receiving and sending telecommunication signals from and to the ground stations and from and to other relay stations.

[0010] The relay stations are at an altitude of about 15 to 25 miles (i.e., within a portion of the stratosphere) and, thus, are capable of transmitting signals to a point on the earth directly below a relay station with a transmission time of about 80 μsec. Means are provided for controlling the lateral movement of the relay stations so that once a pre-determined altitude is reached, a predetermined location of each of the relay stations can be achieved and maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention can be further understood by referring to the accompanying drawing of a presently preferred form thereof, and wherein

[0012] **FIG. 1** is a schematic showing a communications system constructed in accordance with a presently preferred form of the invention.

[0013] **FIG. 2** is a side elevation view of one of the relay stations comprising the invention.

[0014] **FIG. 3** is a view of a portion of **FIG. 2** showing a propulsion system.

[0015] **FIG. 4** is a view of a portion of **FIG. 2** showing another form of propulsion system.

[0016] **FIG. 5** is a view of a portion of a relay station.

[0017] **FIG. 6** is a view of a second embodiment of the portion of the relay station shown in **FIG. 5**.

[0018] **FIG. 7** is a view of a relay station being recovered.

DETAILED DESCRIPTION

[0019] Referring now to **FIG. 1**, the system **10** comprises a ground based portion **12** and an air based portion **14**.

[0020] The ground based portion **12** may comprise conventional telephone networks **16** with branches that are connected to a ground station **18** having suitable long distance transmitting and receiving means such as antenna **20**. The ground based portion **12** may also comprise mobile telephones of well known types such as cellular telephones that may be carried by individuals **22** or in vehicles **24**. The microwave antennae **20** are operative to transmit and receive a telecommunication signal to and from a sub-orbital, high altitude relay station **28** which is located at an altitude of between about 15 to 25 miles.

[**0021**] Preferably, there are a plurality of relay stations **28**; each one being at a fixed location over the earth.

[**0022**] Each relay station **28** contains means for receiving a telecommunication signal from a ground station **20**, individual **22** or vehicle **24** and then transmitting it to another ground station **118**, individual **122** or vehicle **124** either directly or by way of another relay station **130**. Once the signal returns to the ground based portion **12** of the system **10**, the telecommunication call is completed in a conventional manner.

[**0023**] The relay station **28** may comprise a lighter than air device **32**. A suitable device could be an inflatable device such as a high altitude super-pressure balloon of the type developed by Winzen International, Inc. of San Antonio, Tex. The superpressure balloon **32** is configured so that it floats at a predetermined altitude. The configuring is accomplished by balancing inflation pressure of the balloon and the weight of its payload against the expected air pressure and ambient temperatures at the desired density altitude. It has been observed that devices of this character maintain a high degree of vertical stability during the diurnal passage notwithstanding that they are subject to high degrees of temperature fluctuation.

[**0024**] A plurality of tracking stations **36** are provided. The tracking stations include well known means which can identify a particular relay station **28** and detect its location and altitude.

[**0025**] As will be explained, a thrust system is provided for returning a relay station **28** to its pre-assigned location should a tracking station **36** detect that it has shifted.

[**0026**] Referring to **FIG. 2**, each of the- relay stations **28** includes a housing **40** which is supported by device **32**. The housing **40** contains a telecommunication signal transmitter and receiver **44** and a ground link antenna **48**. Antenna **48** is for receiving and sending telecommunications signals between ground stations **20** and the relay station **28**. The relay station **28** also includes a plurality of antennas **52** which are adapted to receive and transmit telecommunications signals from and to other relay stations. The housing **40** also contains a guidance module **56** that transmits the identity and location of the relay station to the tracking stations **36**. It receives instructions from the tracking station for energizing the thrust system. A guidance antenna **58** is provided to enable communication between the tracking station **36** and the guidance module **56**.

[**0027**] A suitable re-energizable power supply Go is mounted on housing **40**, the power supply **60** may comprise a plurality of solar panels **64**. In a well known manner the solar panels capture the sun's light and convert it into electricity which can be used by the telecommunications equipment as well as for guidance and propulsion.

[**0028**] In addition the power supply could also comprise a plurality of wind vanes **68**. The wind vanes may be arranged to face in different directions so that at least some of them are always facing the prevailing winds. The wind vanes **68** can be used to generate electric power in a well known manner which also can be used by the telecommunication equipment as well as for guidance and propulsion.

[**0029**] As seen in **FIG. 4**, an alternate power supply **66** may be provided in the form of a microwave energy system of similar to that which has been developed by Endosat, Inc. of Rockville, Md. The microwave energy system includes a ground based microwave generator (not shown) that creates a microwave energy beam of about 35 GHz. This beam is directed to receptors **80** on the relay **28** and there converted to direct current.

[**0030**] In a manner similar to the solar energy system, the microwave energy system could supply power sufficient to operate the telecommunications system on the relay station as well as provide power for guidance and propulsion. Further, the relay stations **28** may be provided with at least one microwave transmitter and suitable means for aiming the microwave transmitter at a microwave receiving means on another relay station **28** so that a source other than the ground based microwave generator is available to provide microwave energy to the relay stations.

[**0031**] As seen in **FIGS. 3 and 4** the navigation/thrust system for the relay station **28** may comprise a plurality of rockets or jets **90** or propellers **94**. The jets **90** and propellers **94** are arranged in a horizontal plane along mutually perpendicular axes which are supported by pods **100** on the housing **40**. By selective energization of various ones of the jets or propellers the relay station **28** can be directed to and maintained at a pre-determined location over the earth.

[**0032**] If desired, additional jets or rockets **108** or propellers **112** could be located on vertical axes to assist in bringing the relay station to its pre-determined altitude on launch or restoring it should its drift from that altitude be more than an acceptable amount.

[**0033**] The tracking stations **36** and guidance module **56** are operative to energize selected ones of the jets or propellers for selected intervals to return the relay stations **28** to their pre-determined locations.

[**0034**] When the system **10**, is operating the customer will be unaware of its existence. Thus, when a call is placed, the telecommunications signal will be conveyed from the caller's telephone by way of a conventional network to the ground station **18** associated with that location. The microwave antenna **20** will then beam a telecommunications signal corresponding to that telephone call to the nearest relay station **28**. Switching circuity of a well known type will direct the signal to another ground station **120** near the recipient. If the recipient is further, the signal will be sent to a further relay station **130** from which it will be directed to a mobile telephone carried by an individual **122** or in a vehicle **124** or to a ground station **140** near the recipient. The signal received by the ground station **120** or **140** will be transmitted to the recipient's telephone by way of a conventional telephone network. once a communication link is established between two telephones by way of the ground stations and relay stations, the parties can communicate.

[**0035**] Drifting of the relay stations **28** from their predetermined locations will be detected by the tracking stations **36**. The tracking stations **36** will then energize the thrust members on the relay stations **28** to return them to their predetermined locations.

[**0036**] As best seen in **FIGS. 2, 5, 6** and **7** a recovery system **150** for the relay stations **28** is provided. As will be more fully explained, the recovery system includes a deflation device **152** and a remote controlled recovery parachute **154**.

[**0037**] Referring to **FIGS. 2 and 5** one embodiment of the deflation device **152** includes a housing **160** that is formed integrally with the suitable lighter than air device **32**. The housing **160** includes an outwardly extending and radially directed flange **164** that is integrally connected to the device **32** as by welding or by adhesive. The flange **164** supports a downwardly directed, and generally cylindrical wall **168** that supports a bottom wall **172**. As seen in **FIG. 5**, the bottom wall **172** is defined by an open lattice so that the housing **160** is connected to the interior of the device **32** and is at the same pressure.

[**0038**] Near its upper end the cylindrical wall **168** supports an inwardly directed flange **176**. A frangible cover **184** is connected to the flange in airtight relation. This can be accomplished by connecting the cover to the flange by an adhesive, or with a suitable gasket between them, or by fabricating the cover as an integral part of the housing **160**.

[**0039**] The cylindrical wall **168**, bottom wall **172** and cover **184** define a chamber that contains the remote control recovery parachute **154**.

[**0040**] A small chamber **190** is formed on the underside of the cover **184** by a wall **192**. A small explosive pack **194** which is contained within the chamber **190** is responsive to a signal received by antenna **196**.

[**0041**] The parachute **154** has its control lines **198** connected to a radio controlled drive member **200** that is contained within the housing **160**. The drive member **200** may include electric motors that are driven in response to signals from the ground to vary the length of the control lines in a well known manner to thereby provide directional control to the parachute.

[**0042**] To recover the relay station a coded signal is sent to the device where it is received by antenna **196**. This results in the explosive charge **194** being detonated and the frangible cover **184** being removed.

[**0043**] Since the cover **184** is designed to break, the explosive charge can be relatively light so that it does not damage the parachute **154**.

[**0044**] In this regard the wall **192** helps to direct the explosive force upwardly against the cover rather than toward the device **32**.

[**0045**] After the cover has been removed, the gases will begin to escape from the interior of the device **32** through bottom wall **172** and the opening in the top of the housing. The force of air exiting from the device **32** when the cover is first removed will be sufficient to deploy the parachute.

[**0046**] As seen in **FIG. 7**, the parachute **154** will support the device **32** by way of its control lines **198**. As explained above, the relay station **28** can be directed to a predetermined location on the ground.

[**0047**] In the embodiment shown in **FIG. 6** flange **164** supports cover **204** with an annular airtight gasket between them. The cover **204** is held against the flange **164** by a plurality of circumferentially spaced clamping brackets **210**. The clamping brackets are retractably held in engagement with the cover **204** by electrically driven motors **212**. The motors are energized in response to signals from the ground to retract the brackets **210**.

[**0048**] When the brackets **210** are retracted, the pressure of the gases escaping from the device **32** will dislodge the cover and permit the parachute to be deployed.

[**0049**] After the relay station has been serviced, the recovery system **150** can be replaced and the device **32** can be re-inflated and returned to the service.

[**0050**] While the invention has been described with regard to particular embodiments, it is apparent that other embodiments will be obvious to those skilled in the art in light of the foregoing description. Thus, the scope of the invention should not be limited by the description, but rather, by the scope of the appended claims.

What is claimed is:

1. A method for controlling a communications relay station, comprising the steps of:

moving the relay station into a preselected geographic location above the earth within a portion of the stratosphere, the moving step including the step of elevating the relay station into the portion of the stratosphere; and

if the relay station moves from the preselected geographic location, actively changing a lateral position of the relay station within the portion of the stratosphere to return the relay station to the preselected geographic location within the portion of the stratosphere.

2. The method according to claim 1, further comprising the step of providing two-way communication between the relay station and at least one of another relay station within the portion of the stratosphere and a ground station.

3. The method according to claim 1, wherein the relay station includes a free-flying balloon.

4. The method according to claim 1, further comprising the step of determining a current geographic location of the relay station within the portion of the stratosphere, and wherein the step of actively changing the lateral position of the relay station includes the step of laterally moving the relay station from the current geographic location within the portion of the stratosphere to the preselected geographic location within the portion of the stratosphere if the current geographic location deviates from the preselected geographic location.

5. The method according to claim 1, further comprising the steps of:

providing at least two ground stations;

transmitting a telecommunications signal from a first one of the ground stations to the relay station; and

receiving the telecommunications signal at the relay station and transmitting the telecommunications signal to a second one of the ground stations.

6. The method according to claim 1, wherein the step of moving the relay station further includes the step of applying a thrust force to the relay station in a direction in which it is to move.

7. The method according to claim 6, further comprising the steps of:

enabling the relay station to receive and store energy; and

using the energy to create the thrust force and to enable the relay station to transmit and receive telecommunications signals.

8. The method according to claim 7, wherein the relay station can receive and store solar energy.

9. The method according to claim 7, wherein the relay station can receive and store microwave energy.

10. The method according to claim 7, wherein the relay station can receive and store wind energy.

11. The method according to claim 1, further comprising the step of returning the relay station to the earth.

12. The method according to claim 5, wherein at least one of the ground stations is mobile.

13. The method according to claim 1, wherein the relay station is lighter than air.

14. The method according to claim 1, wherein the relay station is inflatable.

15. A method for operating a long-duration, free-flying balloon capable of transmitting signals to a point on the earth directly below the balloon in less than about 140 μsec., comprising the steps of:

directing the balloon into a predetermined geographic location above the earth within a portion of the stratosphere; and

if the balloon drifts from the predetermined geographic location, moving the balloon within the portion of the stratosphere back to the predetermined geographic location within the portion of the stratosphere, the movement having a horizontal component.

16. The method according to claim 15, wherein the balloon is located within the portion of the stratosphere at an altitude that is between about 15 and 25 miles, and a transmission time of the signals is in the range of about 80 μsec. to about 140 μsec.

17. The method according to claim 15, wherein the movement also has a vertical component.

18. The method according to claim 15, further comprising the step of transmitting signals between the balloon within the portion of the stratosphere and a ground communication device.

19. A telecommunications apparatus comprising:

at least two ground stations, each of the ground stations including means for transmitting and receiving telecommunications signals; and

at least one relay station, the relay station including means for transmitting and receiving telecommunications signals from and to the ground stations and from and to other relay stations, the relay station being disposed at a predetermined altitude within a portion of the stratosphere, the relay station being at a fixed predetermined location over the earth for transmitting and receiving telecommunications signals from and to the ground stations and from and to the other relay stations, the relay station further including means for controlling the vertical and lateral movement of the relay station so that, if the relay station moves from the predetermined altitude and fixed predetermined location, the relay station is moved back to the predetermined altitude and fixed predetermined location within the portion of the stratosphere.

20. The apparatus according to claim 19, wherein the predetermined altitude is between about 15 and 25 miles.

21. The apparatus according to claim 19, wherein the means for controlling the vertical and lateral movement of the relay station includes:

first means, the first means being operative to identify the current altitude and location of the relay station;

second means, the second means being operative to identify the predetermined altitude and location for the relay station; and

means for moving the relay station from the current altitude and location to the predetermined altitude and location.

22. The apparatus according to claim 21, wherein the means for moving the relay station includes a thrust system and means for selectively energizing the thrust system.

23. The apparatus according to claim 22, wherein the thrust system includes propellers.

24. The apparatus according to claim 22, wherein the thrust system includes rockets.

25. The apparatus according to claim 22, wherein the thrust system includes jets.

26. The apparatus according to claim 22, wherein the means for energizing the thrust system includes means for receiving and converting solar energy to electric energy.

27. The apparatus according to claim 22, wherein the means for energizing the thrust system includes means for receiving and converting wind energy to electric energy.

28. The apparatus according to claim 22, wherein the means for energizing the thrust system includes means for receiving and converting microwave energy to electric energy.

29. The apparatus according to claim 19, wherein at least one of the ground stations is mobile.

30. The apparatus according to claim 19, wherein at least one of the ground stations is stationary.

31. The apparatus according to claim 19, wherein the relay station is lighter than air.

32. The apparatus according to claim 31, wherein the relay station further includes an inflatable device and means connected to the inflatable device for deflating it while it is aloft.

33. The apparatus according to claim 32, wherein the means for deflating the inflatable device is operative in response to a signal from a remote source.

34. The apparatus according to claim 32, wherein the means for deflating the inflatable device includes:

an opening in the inflatable device;

closing means for closing the opening and being operative to seal the opening against the escape of gases from the inflatable device; and

an explosive charge connected to the closing means, the explosive charge being operative when detonated to remove the closing means from the opening.

35. The apparatus according to claim 32, wherein the means for deflating the inflatable device includes:

an opening in the inflatable device;

closing means for closing the opening against the escape of gases from the inflatable device; and

a plurality of clamping brackets for releasably retaining the closing means in sealing relation with the opening; and further comprising:

at least one electrically driven motor supported by the inflatable device, the electrically driven motor being in engagement with the clamping brackets and being operative when energized to move the clamping brackets so that they release the closing means from the opening.

36. The apparatus according to claim 32, wherein the inflatable device includes a parachute having control lines for controlling its descent when it is recovered.

37. The apparatus according to claim 36, further comprising:

means for deploying the parachute; and

means for connecting the means for deploying the parachute to the means for deflating the inflatable device so that the parachute is deployed when the inflatable device is deflated.

38. The apparatus according to claim 37, further comprising radio controlled means supported by the inflatable device and being connected to the control lines for the parachute, the radio controlled means being operative to provide directional control to the parachute as it descends.

39. The apparatus according to claim 19, wherein the relay station includes a super pressure balloon.

40. A stratospheric relay station comprising:

a navigation system for directing the relay station into a predetermined geographic location above the earth within a portion of the stratosphere and, if the relay station leaves the predetermined geographic location, for moving the relay station within the portion of the stratosphere back toward the predetermined geographic location within the portion of the stratosphere, the movement having a horizontal component; and

a communication system for transmitting signals between the relay station within the portion of the stratosphere and a base station, the communication system being adapted to transmit signals to a point on the earth directly below the balloon with a time for transmission of between about 80 μsec. and about 140 μsec.

* * * * *