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INSTRUCTIONS TO LIGHT KEEPERS ON FIRST-ORDER TRIANGULATION

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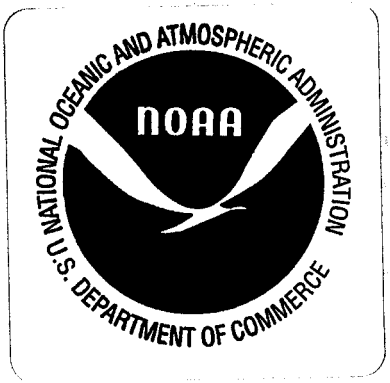
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PREFACE

NOTE TO LIGHT KEEPERS

The purpose of this pamphlet is to instruct you in the work you are to do on a triangulation party. Before you start out alone, be sure you have been taught the uses and adjustments of the compass, heliotrope, and signal lamp. You should learn how to use your compass in orienting the map or sketch given you, so that the north lines on the map point to the true north. The compass needle in most regions does not point true north, and besides, is easily deflected by near-by iron and steel objects.

You should know how to set up and point your heliotrope and arrange the mirrors, how to point your lamp, how to adjust it for focus and pointing, and how to connect the cells for the various kinds of bulbs. You should know how to take proper care of instruments to prevent the metal parts from rusting, and the leather cases from shrinking.

READ THE INSTRUCTIONS IN THIS BOOK CAREFULLY AND OFTEN

So much depends upon the efficiency and faithfulness of the light keeper, that an indifferent one must be disposed of as soon as convenient.

NOTE TO CHIEF OF PARTY

Before a light keeper is placed alone on a station, you should be sure he understands thoroughly the use and adjustment of each instrument required in his work. Detailed instructions should also be given him in the care of instruments. If a light keeper thoroughly understands his apparatus, he will be able to make many of the emergency repairs which become necessary from time to time.

CONTENTS

INSTRUCTIONS TO LIGHT KEEPERS ON FIRST-ORDER TRIANGULATION

INSTRUMENTS

COMPASS

The use of the compass will have been explained to you before you are left alone. To test a compass, compare it with another, known to be correct, or test it on some line the azimuth of which is known. The compass should never be carried with the needle resting on the pivot; there is a device on each compass for lifting the needle off its pivot.

HELIOTROPE

The use of the heliotrope will be explained to you before you start out alone. An undamaged heliotrope needs no adjustment. The only possible lack of adjustment occurs when one of the sighting devices is bent, in which case the line joining the sighting points will not be parallel to the line passing through the centers of the alignment rings. When such a defect exists, the affected part should be removed from the box, straightened, and replaced.

An emergency heliotrope may be made by driving two nails vertically about 2 feet apart into the upper

surface of a board, the heads of the nails to be used as sighting points for the beam of reflected sunlight. Place the board on the stand, align the heads of the nails with the station of the observing party, and make sure that the line between the two nails is plumbed over the mark at your station. Next fit a narrow strip of paper over the forward nail, the top of the strip being back of the nailhead and projecting slightly above it. With a common mirror a few inches in diameter held in line with the nailheads, throw the reflected rays of the sun along the line of the nailheads, so that the shadow of the head of the rear nail falls on and exactly covers the head of the forward nail. The paper strip mentioned above enables one to easily make this exact contact. An emergency heliotrope such as this has been satisfactorily observed upon from a station 40 miles away. The center of the mirror should be held approximately in line with the nailheads to avoid eccentricity of the light shown the observer.

ELECTRIC SIGNAL LAMP

The electric signal lamp, supplied with current by dry cells, has almost entirely superseded the acetylene lamp which was in use for many years. The 1924 model of electric signal lamp was designed for regions where the lines of sight are not greatly in excess of 25 miles and where it is important to have the outfit as light as possible. This lamp has a reflector 5½ inches in diameter. A larger lamp, with a reflector 7

inches in diameter, is used where a more brilliant light is needed on account of long lines or hazy atmosphere. A third lamp, with a reflector 12 inches in diameter, is furnished only by special request. It is used with bulbs of high voltage and high amperage, requiring a considerable number of cells at one time to give the necessary voltage, and because of the high amperage the cells are exhausted rapidly. A fourth type of lamp is for use with an ordinary flash light on short lines.

OUTFIT FOR LAMP

Your outfit for the electric lamp should include the following:

Ammeter, pocket, for testing cells.

Box for battery, waterproofed by a cover of tin or painted canvas.

Cells, dry, 10 to 24.

Connectors for battery sufficient to connect up 10 to 24 cells.

Lamp, electric, in case, with screw driver, gimlet, extra bulbs of the sizes needed, and screw for holding lamp to tripod head.

Tarpaulin, about 10-ounce, waterproofed by painting with boiled linseed oil.

Wire, copper, No. 18, with waterproof insulation to lead from cells to lamp, 20 feet.

DESCRIPTION OF LAMP

Reflector.—The reflector is of frail construction and must be handled carefully to prevent rusting and scratching. Do not touch the reflector with the hands

or polish it with anything except dry, soft chamois skin or clean tissue paper.

Sighting tube.—This tube has a sighting pin in the forward end and a notch in the middle of the semicircular wall which half closes the eye end. The adjustment is made by shifting the bracket which supports the rear end of the tube until the tube is in the proper position. Then the bracket is clamped by means of the knurled nut, which is about 1½ inches below the rear end of the sighting tube. The tube may be moved backward or forward in the outer tube without disturbing the adjustment if the brackets are firmly secured to the lamp box.

Focusing device.—This is the small knurled thumbscrew about one-half inch to the right of the rear of the bulb socket. This screw passes through a collar which encircles and is made fast to the bulb socket. By turning this screw in and out the position of the bulb is changed in relation to the reflector.

BATTERY CONNECTIONS

With the lamp properly pointed and focused, the brilliancy of the light will depend upon three factors—the number of dry cells used, the method of connecting them, and the kind of bulb used. Different methods of connecting the cells will be described first.

Figure 1 shows several cells connected in series, the carbon pole of one being connected to the zinc pole of the next. When thus connected, each added cell

increases the voltage, and the total voltage is the sum of the voltages for the individual cells. There is a proper voltage for each lamp bulb. If the voltage is too low, a dim light will be obtained; while if it is too high, the bulb will be burned out.

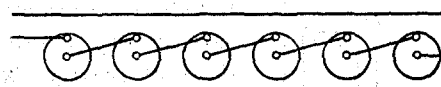

FIG. 1.—Cells connected in series

There will be 24 amperes and 9 volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

Figure 2 shows cells connected in parallel, all the carbon poles being joined together and all the zinc poles. This method increases the amperage of the circuit, but the voltage is the same as that of a single cell. In other words, it is equal to a battery with the same voltage as the individual cell but as many times larger as there are cells in the connection, thereby increasing the number of hours the lamp can be kept lighted.

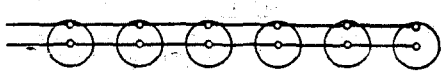

FIG. 2.—Cells connected in parallel

There will be 144 amperes and 1½ volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

Figures 3, 4, and 5 show different series-parallel connections and should be studied carefully by the light keeper. These diagrams are explained in detail in connection with the description of the different bulbs.

BULBS

Low-amperage bulbs.—The most commonly used bulb is the one rated at 0.6 ampere and 3.7 volts. This

bulb is supplied by the office on requisition and requires the amperage and voltage marked on the base. When it is used in the size of signal lamp which has a reflector 5½ inches in diameter, it gives very satisfactory results on lines which do not greatly exceed 25 miles in length. In case it is found necessary to have a brighter light on account of hazy atmosphere, and a larger lamp is not available, it is possible to use a 1.25-ampere bulb (described on the following page) in this lamp. Do not use the larger bulb in the small lamp if the larger lamp is available, however. For ordinary cases with the small lamp and the 0.6-ampere bulb, 2 units of new cells, each unit containing three cells connected in parallel (see fig. 3), will be sufficient to give a very satisfactory light for 6 hours a day for 10 days. Although rated at 3.7 volts, these bulbs will stand 4.5

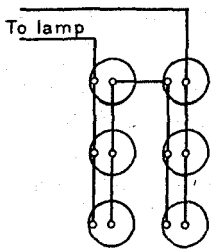

FIG. 3.—Series-parallel connection of 6 cells in 2 units of 3 cells each

There will be 72 amperes and 3 volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

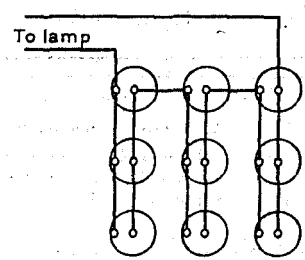

FIG. 4.—Series-parallel connection of 9 cells in 3 units of 3 cells each

There will be 72 amperes and 4½ volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

volts, or three units of new cells, since the voltage of an ordinary cell, or of a unit of two or more cells connected in parallel, is about 1½ volts. Four units of new cells would have a voltage of 6, which would burn out a bulb of this type.

After a period of use of the two units of three cells each the voltage will decrease and the cells will no longer furnish a satisfactory light. A third unit should then be added and later a fourth unit. When the four units no longer give a sufficiently brilliant light, because of the drop in voltage, the two oldest units should be removed and replaced with one new unit. Be careful not to connect up enough cells to give a voltage more than the bulb will stand. After a period of rest the cells removed may be used again with others of about the same degree of exhaustion. Very weak cells should not be used in combination with new ones.

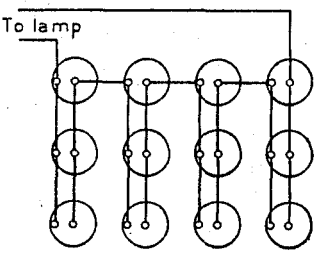

FIG. 5.—Series-parallel connection of 12 cells in 4 units of 3 cells each

There will be 72 amperes and 6 volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

High-amperage bulbs.—The office also furnishes a bulb rated at 1.25 amperes and 3.7 volts. This bulb is the same size as the 0.6-ampere bulb and can be used

with the same battery. It is to be used in cases where the 0.6-ampere bulb will not give a sufficiently powerful light and is to be fitted ordinarily in the signal lamp having the 7-inch reflector. This bulb will consume twice as much current as the 0.6-ampere bulb and should not be used where the other will be satisfactory. When cells are new, the 1.25-ampere bulb should be supplied by two units connected in series, each unit consisting of three or four cells connected in parallel, extra units being added as the cells weaken. (See figs. 3, 4, and 5.) Three units of new cells in series will give as great a voltage as the bulb will stand, since it is rated the same in this respect as the 0.6-ampere bulb.

High-voltage bulbs.—The office will also furnish for special cases a bulb rated at 2 amperes and from 6 to 8 volts. This bulb consumes such a large amount of current that it is not economical or practical except in cases where the observer desires not only a brilliant light, but also a light with its beam slightly diffused. The use of this bulb necessitates a very large lamp which the office is able to furnish. The occasions when this lamp is needed are rare, and such lamps are sent to the field only on special request. With fresh cells, 5 units of 4 cells each should burn well for about 20 hours, after which the brilliancy will be reduced noticeably. Other units should be added one at a time as needed. When 8 units do not give the required amount of light, the older cells should be thrown away and

fresh units used. A comparison of the number of cells used with this bulb and with the smaller bulbs readily shows why this lamp is not practicable. It gives a beam only slightly more intense, and it requires a large number of cells, which is undesirable when weight is a serious consideration.

Commercial bulbs.—In case of emergency, when the bulbs furnished by the office are not available, the commercial automobile headlight bulbs, rated at the required voltage, may be used. They use much more current than the bulbs of the same voltage furnished by the office, and the light is not as satisfactory because the rays of light can not be so well concentrated into a beam due to the larger space occupied by the filament. Automobile bulbs are usually rated at 6 volts and may be of the single or double contact type. The signal-lamp socket is adapted for the double-contact bulb only. Bulbs other than the double contact, single filament type will require alterations in the lamp socket, which are difficult to make with satisfaction.

TESTING CELLS

Use the pocket ammeter to test the cells as they are used. Cells which show no energy should be thrown away; if they are placed in circuit with other cells they cause more resistance to the current and tend to reduce all to an average voltage. In general, cells of less than 4 or 5 amperes will be of no use.

ADJUSTMENTS OF THE LAMP

Aside from the electric connections there are only two adjustments needed for any of the three lamps—one for focus and the other for the sighting device—and these should be tested frequently.

Focus.—The lamp must be properly focused at all times. No matter how brilliant the filament of the bulb may be, the light will not be effective at any distance unless well focused. Each bulb will be found to require a slightly different focus, and this is true even of the same kind of bulbs of apparently the same size, because the position of the filament relative to the base of the bulb is rarely exactly the same. Therefore, focus the lamp every time the bulb is changed and refocus after the lamp has been shipped or carried by truck or pack horse, since the vibration while traveling will quite likely cause a change.

The focusing adjustment is made by the screw socket into which the bulb fits (see p. 4). Focusing can be done either at night or during the day. At night focusing is best done by directing the light upon a flat surface, such as a tarpaulin or tent, about 100 feet away and turning the adjusting screw until the brightest part of the disk is but little larger than the lens of the lamp. As much light as possible should be concentrated within this area.

During the day the focusing can be done by standing about 100 feet away from the lamp with your eyes in the path of the beam and have some one turn the focus-

ing screw back and forth until that point is found where (1) the light is brightest, (2) there are no black rings or spots on the reflector, and (3) the "spread" of the bright beam is little more than 1 foot, as found by moving the eye up and down and sidewise in the path of this beam. The lamp is then in focus.

Sighting tube.—The center of the most brilliant part of the beam must be pointed to the observer, and if the sighting tube is used in pointing, its sights must be parallel to the light beam. To adjust the sights by night, point the light to some object near enough to outline the central bright beam and after loosening the knurled nut which holds the sight tube bracket, adjust the tube so that the sights point to a spot as far above the center of the beam as the sighting tube is above the center of the reflector. Then tighten the nut to hold the bracket and tube in that position.

This adjustment may also be made during the day. Place a stake in the ground in the path of the light and make a mark on the stake at the point where the reflector shows the brightest. This point may be found by moving the eye up and down and sidewise just back of the stake in the same manner as when focusing the light. Then adjust the sight tube so that the sights point to a spot the same distance above the mark on the stake as the tube is above the center of the reflector. Adjustments of the focus and the sight tube may be advantageously made at the same time.

When the adjustments are properly made, the bright beam of the light will go to the observer if the sights are pointed at him. At night the pointing may be made upon the observer's light by sighting accurately along the beam—from directly above it for line and from the side for elevation.

A light not properly pointed may either be invisible to the observer or may cause errors in the observing which can not be detected until all the stations of the triangle have been occupied, and thus may cause great delay and expense.

USE OF AUTOMATIC LIGHT

When automatic lights are used, a great deal depends upon the care and pains that are taken when the lights are posted. Through any one of a number of mistakes or oversights the lamp may fail to light, and thus hold the party back until someone can be sent to the station to remedy the trouble. Therefore, when posting a light be careful that everything is as it should be before you leave, checking yourself by using the list of operations pasted on the inside of the back door of the lamp.

"*Warning*" *notice* (Form 620).—The first thing to do is to tack the warning notice on the stand in a conspicuous place. By doing this first you will not need to pound on the stand and disturb any adjustment later.

Plumbing of station.—Plumb over the station carefully. This should be done every time the station is visited because the stand may have been disturbed.

Testing of focus and sighting tube.—Be sure the bulb is in focus and that the pointing device is correctly adjusted. These two adjustments are very important and should be made at each station because they are easily disturbed by vibration during the traveling from station to station.

Battery.—Test each cell with your ammeter. If any are found weak, replace with new ones, saving the old cells, if not too weak, for use where a lamp is watched by a light keeper.

Wire connections.—Test all wire connections to cells and lamp. See that all nuts on binding posts are tight, that the poles of the cells do not touch any metal part of the box, and that connecting wires do not cross or come in contact with any metal. Rubber-insulated wire should be used where exposed to the weather. A short circuit may occur unless caution is used.

Signaling switch.—Provide a good contact between the signaling key and the button beneath. If the key is loose, it can be tightened by removing the two screws which hold the switch to the bottom of the box and tightening the nut on the bottom of the switch.

Bulb.—Test the bulb by moving the contact arms of the time switch. If the bulb does not light, it may

be due either to defective wiring or to a defective bulb. In case it is necessary to replace the bulb, be sure to focus the new one.

Contact surface on clock.—Clean the contact surface on the time switch of any corrosion or moisture, so there will be a good contact throughout the period when the light will be used.

Winding of clock.—Be sure the clock is wound. This may seem a trivial matter, but it is one that can be easily overlooked. The clock should be wound up fully each time the station is visited, because it may not be convenient to visit the lamp again for several days. Be careful not to wind the clock spring too tightly.

Setting the clock.—Set the arms of the time switch at the proper time and period and make certain you have not mistaken night for day on the dial. Be sure the thumbscrews *C* and *D* (fig. 6) are very tight to prevent any slipping. Figure 6 is a diagram of the time switch and arrangement of cells with directions for setting the time switch.

Door of lamp.—Make sure you have opened the front door of the lamp. It should be fastened open to keep the wind from closing it.

Covering of battery box.—Before pointing the lamp cover the battery box with your battery tarpaulin and weight this down with rocks to keep it from blowing off.

Pointing of the lamp.—This should be left as the last operation, because it is one of the most important

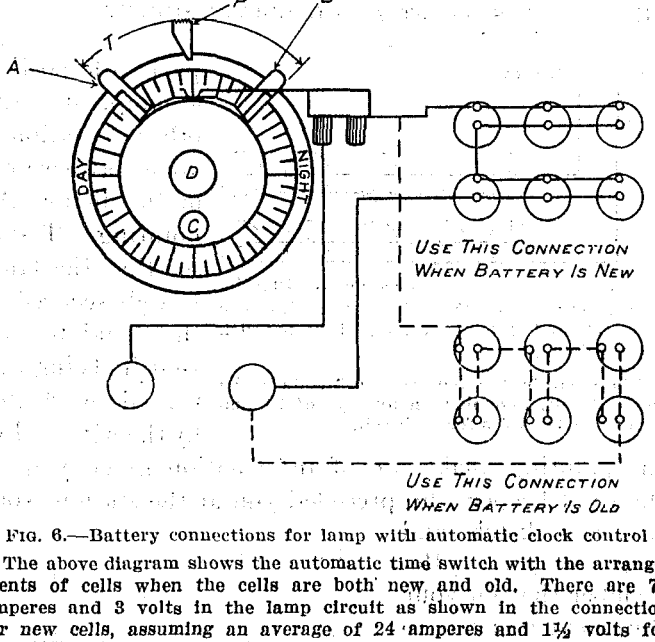

FIG. 6.—Battery connections for lamp with automatic clock control

The above diagram shows the automatic time switch with the arrangements of cells when the cells are both new and old. There are 72 amperes and 3 volts in the lamp circuit as shown in the connection for new cells, assuming an average of 24 amperes and 1½ volts for each cell; but 30 amperes and 3 volts in the lamp circuit as shown in the connection when the cells are old, assuming an average of 15 amperes and 1 volt for each cell. *A* is the arm used to indicate the time at which the light is to come on. *B* indicates the time that the light is to go off. *C* is a thumb screw which when tightened holds the two arms *A* and *B* in their relative position. *D* is a thumb screw which when tightened holds the arms *A* and *B* fixed in relation to the dial and the dial fixed in relation to the pointer *P* and the clock mechanism. *P* is a pointer which indicates the time of day. *T* is the distance between *A* and *B*, or the time that the light is to burn. To set the time switch, loosen *C* and *D*, hold bevelled edge of arm *A* on any hour line and move arm *B* until the arc *T* indicates the desired number of hours the light is to burn. Tighten *C*. Turn the entire switch until the pointer *P* indicates the time of day at which the setting is made, then hold the dial firmly and turn the arm *A* until its bevelled edge is on the hour at which the lamp is to light. Tighten *D*. Check settings carefully and make sure that *C* and *D* are *tight*.

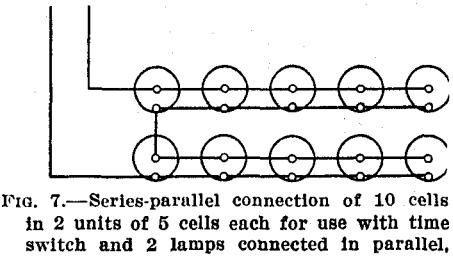

FIG. 7.—Series-parallel connection of 10 cells in 2 units of 5 cells each for use with time switch and 2 lamps connected in parallel, when cells are new

There will be 120 amperes and 3 volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

parts of posting a lamp, and any other operation if done afterwards might disturb the pointing. Test to see that the lamp is well secured to the stand to prevent its being disturbed or shaken by the wind. For the pointing, make use of information given you by the light keeper who preceded you at the station, your progress sketch, and your compass. Remember that on your judgment depends to a large extent whether or not the light will be correctly pointed toward the observer.

If you should be sent to a station to investigate an automatic lamp which has failed to operate, look into every adjustment carefully, so that you can enter

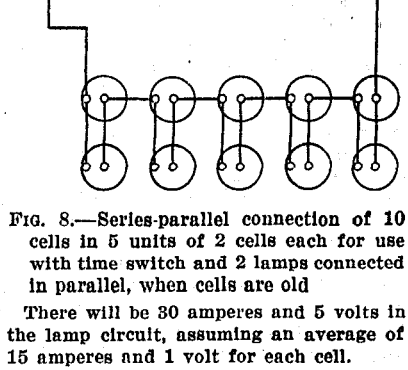

FIG. 8.—Series-parallel connection of 10 cells in 5 units of 2 cells each for use with time switch and 2 lamps connected in parallel, when cells are old

There will be 30 amperes and 5 volts in the lamp circuit, assuming an average of 15 amperes and 1 volt for each cell.

the cause of the failure in the light keeper's "Record Book." (See p. 37.)

The following is a list of reminders for posting an automatic light, a copy of which should be found pasted on the inside of the rear door of the lamp. Before leaving an automatic lamp be sure that you have—

1. Posted warning notice on stand.
2. Plumbed lamp over the station.
3. Tested focus.
4. Tested sighting tube.
5. Tested cells with ammeter.
6. Tested all wire connections.
7. Made contact on signaling switch.
8. Tested bulb.
9. Cleaned contact surface on clock.
10. Wound clock.
11. Set clock properly and checked the setting of the pointer for night or day.
12. Opened and secured front door of lamp.
13. Covered battery box.
14. Secured lamp to stand and pointed light.

MISCELLANEOUS NOTES

1. Do not have long wires leading from the battery to the lamp, as they only increase the resistance of the outer circuit. However, you should have enough slack in the wires so that rain water can not run down the wires into the battery box.

2. Be careful that metal parts of cells and connectors do not touch where they should not and that connectors are tightly fastened to cells.

3. See that cells do not get wet; have slats nailed on the bottom of the battery box, if of wood, so that moisture will not be absorbed from the ground or platform.

4. Inform the chief of party of your need for cells or bulbs far enough ahead so there will not be undue expense or delay in supplying you.

5. To avoid any confusion in the connections, place all poles of the cells in a certain direction, as shown in Figure 3. If cells with the Fahnstock clips are used, straight wires can be employed as connectors and the wiring simplified, but they are often not available except when cells are ordered in large lots.

6. When shipping the lamp and cells be sure they are well packed and that the cells can not become short-circuited by loose pieces of metal or wires left in the box. All the nuts for the binding posts on the cells should be screwed down tight, so they will not be lost. Keep on hand a few extra nuts from dead cells.

INSTRUCTIONS FOR SIGNALING

INTERNATIONAL MORSE ALPHABET

A .—	J .———	S ...
B —...	K —.—	T —
C —.—.	L .—..	U ..—
D —..	M ——	V ...—
E .	N —.	W .——
F ..—.	O ———	X —..—
G ——.	P .——.	Y —.——
H	Q ——.—	Z ——..
I ..	R .—.	

The notations for numerals will be dispensed with and the numbers spelled out when required.

The International Morse ("Continental Code") differs from the American Morse in that there are no "spaces" between the elements of the letters.

The alphabet must be committed to memory; also, which is more difficult, *all letters must be quickly recognized by seeing their elements.* Perfection in this matter will eliminate much trouble and misunderstanding, as most of the difficulty is due to the receiver's inability to recognize a letter before the next one has begun.

INSTRUCTIONS FOR USE OF CODE

Dots should be short, just long enough to permit the light to be seen clearly. For dashes, the light should shine for about two seconds.

The duration of darkness between elements of letters should be one second; between letters, three seconds; and between words, five seconds. It is not important that these periods should be absolutely observed, but the relative proportion should be maintained. Moreover, a uniform speed should be maintained in sending, for varying speeds make the receiving of the message difficult. Use the signaling key on the lamp for all signaling. For signaling with the heliotrope a large piece of cardboard should be used, so that all direct sunlight is cut off from the mirrors between the flashes.

Calling.—A light keeper calls the observer or another light keeper by sending his own letter until answered.

The observer calls a light keeper by showing a steady light to him, whether by helio or lamp. A *steady light from the observer's station* means either that he wishes to send you a message or that your light is not satisfactory. First, inspect your light and then answer the call. If the reason for the call from the observer was your unsatisfactory light, the observer will O. K. by dots as soon as the trouble is corrected and will then turn off his light.

Answering calls.—A light keeper answers a call by a series of one-second dots (not more than seven), then, *with his light steady on the observer*, watches for the signal by aid of the binoculars if necessary. When two light keepers are so located that each is able to see the light intended for the other, both must answer when called, then the letter of the light desired will be sent by the observer.

Receiving messages.—If the lights are faint, before beginning a message give the one to whom it is sent time to steady his binoculars on the light before cutting it off. Darken the light for about five seconds before beginning message. The practice of sending dots before darkening the light is often confusing on long lines and should not be practiced unless authorized by the chief of party. Do not cut off your light while receiving a message.

All messages are to be repeated by the receiver, except in case of messages from light keeper to observer. Here the observer will answer by sending one-second dots. NEVER REPEAT A WORD UNLESS YOU ARE SURE IT IS RIGHT. This is a decided annoyance to the observer and a source of a great deal of trouble. If an observer knows that a message has not been received, he is at least in a position to know what to do to remedy matters. SHOULD YOU FAIL TO GET THE FIRST PART OF A MESSAGE, BREAK IN WITH "R." DON'T WAIT UNTIL MESSAGE HAS BEEN COMPLETED. If first part of message has been received, repeat words you are sure of, then send "R" for remainder. Where lights are faint or light keepers not skilled in receiving messages, it is better for the observer to send one word at a time and have that repeated before proceeding to the next.

CODE SIGNALS

A series of one-half-second dots means "I have made a mistake and will begin again."

A series of one-second dots means "I understand your message."

"R" means "Repeat your message, I could not get it."

Light keepers in relaying messages refer to observer as "O."

SIGNALS TO BE USED BY THE OBSERVER TO A LIGHT KEEPER

"A" means "Wait a while."

If the observer sends an "A" after 10 p. m. it means that the light keeper is to stay on the tower and keep a sharp lookout until called again. Should this be followed by an "L" it signifies that the light keeper is to leave the lamp burning, pointed to the observer, and leave the station for the night. If you have an automatic lamp, the observer will instruct you at what time to set the switch to cut off the light. At the next observing period the light keeper should show to the same station unless he has received further orders but should be alert for a message from either that station or from the next station on the observer's schedule.

"AA" means "Stand by; will need you soon." (10 or 20 minutes.)

"N" means "Your light is too faint."

"M" means "Moderate your light; it is too bright."

"Z" is the distinctive letter of the observer. It is O. K'd by repeating backward to the observer, thus: . . — —. A light keeper receiving a "Z" knows that the observer is at that place and shows to him.

"Get," followed by the name of the station, means "Get person at that station by calling him and tell him where observer is."

"ST" means "Stop showing light to this station and show light to the station to which the observer goes, which is indicated on the written schedule of the

observer's moves, a copy of which has been furnished to you."

"ST," followed by the name of station, means "Stop showing light to this station; at the next observing period show to the station named and look for the observer's call."

"ST," followed by name of station and a number, means "Stop showing light to this station; show to the station indicated and look for the observer's call on the date corresponding to the number."

"THD" means "Have finished with you for this observing period; show to this station again at the next observing period."

"DG" means "Done where you are; go to your next station as indicated on your schedule of moves and there show light to the observer at his old or new station according to the schedule."

"DG," followed by name of station and a number, means "Done where you are; go to station named, show light, and look for the observer's call. The number indicates the date on which the observer will need your light at his new station." If no number is given you, you are to show light from your new station at the first observing period after you reach the new station.

"DGK" means that the move indicated by the "DG" will be made by truck, which will call at the nearest accessible point for you and take you to your next station.

"DGRK," followed by the name of a railroad station which is near your next station, means "Done with you where you are; go by train to the railroad station mentioned, where the truck will meet you and take you the remainder of your way to your station."

"DGKR," followed by the name of a railroad station near your present station, means "Done with you where you are; go by truck to the railway station named and from there go the remainder of the distance by train and private conveyance."

"ST" or "DG," followed by an "L," means "Leave your lamp burning to-night; but to-morrow follow instructions given by the ST or the DG."

"Fini" means "Have finished on you; obey written instructions."

"Money," "Mail," etc., followed by name of place, means "The article is at the place named."

"No" means "You have not repeated message correctly. Correct message will again be sent you."

SIGNALS TO BE USED BY LIGHT KEEPER TO OBSERVER

"Money," "Cells," "Bulbs," etc., means "I am in need of same." Other necessary messages will be spelled out in full.

SIGNALS TO BE USED BY A LIGHT KEEPER TO ANOTHER LIGHT KEEPER

"O," followed by the name of a station, means "Observer is at the station named; show to him at once."

GENERAL CONSIDERATIONS

Keep a sharp lookout for signals at all times; if lights are faint, look for signal every few minutes with binoculars.

"N" signals may be sent to you at any time if your light is poor.

Be careful to sight your lamp and heliotrope accurately; if in doubt, send your letter and the observer will show you a light.

Keep your heliotrope and lamp in good condition. When the air is clear, a poor light may possibly be seen, but when it is hazy only a clean lamp and reflector will give good results.

At every opportunity get the correct standard time and keep your watch within a few minutes of it.

Be extremely careful not to have lanterns, fires, or other extra lights about the tower or stand during the observing periods. They may be mistaken for the signal light by the observer. Frequently, they can be seen by the observer even though they are at the foot of the tower.

When your line is 10 miles long, or less, watch for an "M," meaning that your light is too strong and should be reduced by reducing the strength of the current supplied to the lamp.

ROUTINE WORK AT STATION

The first thing to do after reaching your station is to check the plumbing of the hole in the top of the

stand, which should be directly over the center of the mark. The plumbing of this hole, into which is fitted the screw which holds the heliotrope or lamp to the stand, may have been disturbed and should be checked each day before using. You will not be able to test the plumbing of towers. Use the hole in the top of the light stand made for your lamp by the building party. The observer will check the plumbing when he comes to your station.

The next thing to do on reaching your station is to try to locate all the stations to which you will show. By doing this at the first opportunity, and not waiting until the the time you expect you heliotrope or light to be needed on a line, you will avoid causing delays to the observing party. Where smoke, clouds, and fog are encountered, the value of getting your pointings on the clear days is evident. The progress sketch showing the triangulation scheme and the descriptions of the adjacent stations will be of great use to you in finding the different stations to which you will show. Orient your sketch by your compass, taking into account the magnetic variation, or by a direction to some station which you can see and identify. After finding the stations in this manner you should hold the directions to them by lines marked on the stand or by any other means practicable until you can verify the directions by seeing lights at the stations.

Your work on the tower or stand begins at 2 p. m. From then until 4.30, unless instructed otherwise by

the observer, you will show your heliotrope all the time if there is sun enough to make a shadow. If your heliotrope is pointed with care, a faint sun is just as good as a bright sun on comparatively short lines; also, if you get only a faint sun for a short time every 10 minutes or so it may be sufficient for the observer to use. It is not for you to decide whether the sun is bright enough or whether or not the observer can see the reflection. In case you get no "Z" from the observer, keep a sharp lookout for the observer's call from his next station, as he may have moved without being able to notify you.

When you are on a wooded peak and there has been a delay in seeing the observer's light, watch carefully for him, for the light may be obstructed close to your station and you may be able to see the call from the top of a tree or from some other point on the mountain. In other words, you can not be absolutely sure the line is open unless you have seen a light from the other station, and unless you are sure keep trying to get the observer's call by watching very closely. When in trouble about the direction of the lines, always keep watching for calls from stations other than the observer's, for the observer may be sending you a message through one of the other light keepers.

When the observer's heliotrope is once seen, set your telescope on it and fasten or mark your heliotrope so you will have the direction of the line, even if the weather should become cloudy or smoky. Then make a

more careful pointing of your heliotrope, using thin wedges if necessary to get the proper elevation. Mark the place on the stand where each wedge belongs and also mark the wedge to show how far it is to be pushed under the heliotrope; also mark along the side of the heliotrope box for the direction. Then you can replace your heliotrope exactly after it has been disturbed. The lamp may be set and pointed by the lines made for the heliotrope. Remember that the vertical pointing of a heliotrope or lamp is just as important as the horizontal pointing.

There are different methods for holding directions to other stations after they have been identified by seeing lights or heliotropes at them. One method is to draw lines on the top of the stand; another, if you are at a tower, is to drive nails in the railing around the platform in line with the other stations; and a third method, if the light is not being shown from a tower or a sharp peak, is to drive a stake in line with each of the other stations, the top of each stake being at such a height that when the light is pointed at the stake top it will have the correct elevation and direction for the pointing on the corresponding station.

After your heliotrope is correctly pointed it will require constant attention. Otherwise the light will not be steady as seen by the observer.

An effort will be made to send you "THD" as often as practicable. It may not always be possible because the sun may not be shining at the observer's station.

At night your lamp should be set up and lighted 10 minutes before sundown. This is important, and every effort should be made to be punctual. As soon as it is dark enough to signal, the observer will give you a "Z," which should be acknowledged in the usual manner. This will give you an opportunity to check the pointing of your lamp. From this time you should keep a close watch for the observer's light and for other lights, because the observer may be calling you through some other light keeper. If you have not received further instructions from the observer keep your light burning until 11 p. m. At that time begin sending one-second dots (about 20 at a time) and remain on the lookout for signals for 15 minutes (until 11.15 p. m.). If no signals are received, see that the light is burning well and then leave the tower for the night. If you have an automatic lamp, the observer will usually have given you instructions as to when the clock should be set to turn the light off.

If you are showing light at a station which will be occupied by the observer or by another light keeper later, you should carefully write the name of the station on each mark on the stand used in pointing your light, or if stakes were used for this purpose they should be left in place. Make a note of any useful information, such as directions to nearest water, etc., and place it in a tin can on the mark under the stand or tower.

Before the observer arrives you should find out the name and address of the owner of the land on which

the station is located, being careful to get the correct spelling of the name. Also find out if possible the numbers of the section, range, and township in which the station is located. This information is for the description of the station which will be published later. Also find the location of the reference marks at the station.

Remember that your duties do not consist entirely in showing light to the observer. It is also your duty to meet the observing party when it comes to your station and assist in making camp and in packing the observing equipment to and from the station. It may be necessary for you to cut or clear a trail to the station. This should be done before the observer arrives. If clearing must be done on any of the lines, you should do it if possible, notifying the chief of party or observer if you are not able to do it all before the lines are to be used, so that help may be sent you or the schedule may be changed.

If no tower is to be used and the ground is not well leveled off around the stand so the observer can walk around it easily while observing, you should construct a level place around the stand, using rocks, timbers, earth, etc., being very careful that none of the rocks or timbers bear against the legs of the stand and that a smooth, solid, level footing for the observer is provided.

Keep your tents, mess outfit, instruments, and other articles of equipment clean and in order.

Remember that the towers are built with the least material required for safety; that the signal notices apply to light keepers as well as to other people, and therefore you should in no way weaken the scaffold by removing any of its parts.

MOVING TO NEXT STATION

You should make an extra effort to move between stations as rapidly as possible to prevent holding back the observing party longer than is necessary.

In addition to the sketches showing the scheme of triangulation as located by the reconnaissance party, you will be given descriptions of the stations which will enable you to move from station to station. You will be given lists of the triangulation stations in the order in which they will be occupied by the observer, and you will also be given a statement of your own moves and, for each of your stations, the line or lines over which you are to show a light. This information will be tabulated in the following form:

Schedule of moves for observer and light keepers .

Observer	Light keeper "B"	Light keeper "D"	Light keeper "H"	Light keeper "K"	Light keeper "P"	Light keeper "U"	Light keeper, extra
Haystack	Rawhide	Hobbs	Willow	Coleman	Notch	Chugwater	-------
Coleman	Haystack	do	do	do	do	do	-------
Notch	do	Whitaker	Ragged	do	do	do	-------
Chugwater	do	do	do	do	do	do	-------
Whitaker	Wadhill	do	do	Greentop	do	do	-------
Ragged	do	do	do	do	do	do	-------

Each light keeper in the party will be assigned a letter so chosen as not to be identical with or similar to any of the code letters. In the table above the stations which each light keeper is to occupy in succession are shown in the vertical column under his letter, and the location of the observer and the various light keepers at any time is shown in a horizontal line of the table.

Thus, when the observing party is at Haystack, light keeper "B" will be at Rawhide, "D" at Hobbs, etc., and will be showing their lights to Haystack; when the observer moves to Coleman, "B" moves to Haystack, and the other light keepers keep their stations, changing the pointing of their lights so as to show them to the observer at Coleman.

NOTE TO TRUCK DRIVER

Truck drivers should bear in mind that their duties do not consist merely in moving light keepers and in keeping their truck in good repair.

When a truck driver moves a light keeper to a new station, he is responsible for the light keeper getting to his station in the least possible time. He should help the light keeper pack his outfit to his camping spot if necessary and then go with him to the station to see if all lines are clear. There have been instances in the past of a truck driver leaving the light keeper at the foot of the wrong mountain or at a place from which the station was very inaccessible when, if he

had investigated, he could have taken the light keeper to a spot from which the station could be easily reached.

DOUBLE OBSERVING PARTY

With two observing parties the work of the light keeper is somewhat more complicated, since he must show lights to two stations at once and keep the moves of two observers in mind. The same signals will be used as with a single observing party, except that party No. 2 will send "ZZ" instead of "Z" and will be spoken of in signaling as "OO" instead of "O." You must use your judgment in interpreting signals. For instance, if "O" sends "DG 10" and you are being worked on by "OO" also, you will remain where you are until you receive a "DG" from "OO." The "DG 10" simply means that "O" will be ready to work on your next station on the tenth. In the above case you should signal, if possible, "OO not done," or something to that effect.

Since it is impossible to foresee the relative speeds of the two observing parties, it will be necessary at times for the chief of party to mark adjacent stations on your schedules as "a" and "b;" in such cases it will be necessary for you to finish at the station marked "a" before going to "b," even though you know the other observer is waiting for your light from "b."

When showing two lights, mount one as usual on the observing stand or superstructure. Then mount the other on the top of the first lamp, using the hole pro-

vided in the top of the bottom lamp into which to fit the screw. Since the height of the helio and lamp must be known, you must keep a record to show which lamp, whether upper or lower, was pointed to the various stations on your schedule. It will simplify matters if you always show the lower lamp to the "O" party and the upper one to the "OO" party, or vice versa, keeping a record only when one lamp is used.

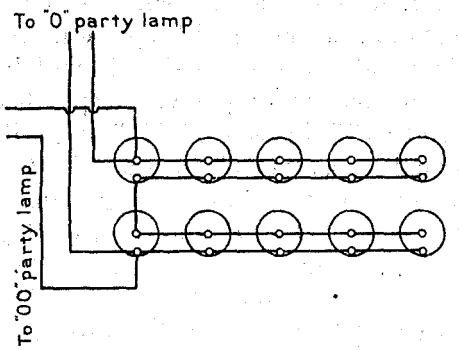

FIG. 9.—Series-parallel connection of 10 cells in 2 units of 5 cells each for use with 2 lamps connected in parallel, when cells are new, on a double observing party using tended lights

There will be 120 amperes and 3 volts in the lamp circuit, assuming an average of 24 amperes and 1½ volts for each cell.

If one observer should be at your stand and there is no superstructure on the tower, he will line in your lamp on another stand placed on line between your station and the other observer.

Figures 9 and 10 show the arrangement of cells for use of two lamps connected in parallel. Ten new cells with series-parallel connection of 2 units of 5 cells each (fig. 9) should give a satisfactory light for 16 days, burning 6 hours a day with a 0.6-ampere bulb.

If you are posting automatic lights at a station for a double observing party, the method of procedure

will be the same as for posting one light, except that you will attach one wire from each lamp to each of the two binding posts on the lighting device. This arrangement connects the lamps in parallel. You will need more cells for two lights. In most cases 10 cells (the capacity of the battery box) connected in 2 units of 5 cells will give sufficient light. (See fig. 9.)

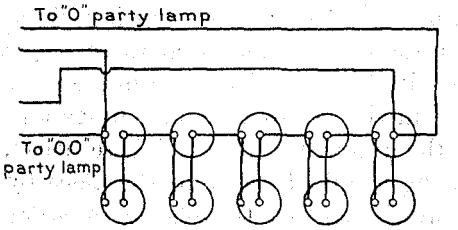

FIG. 10.—Series-parallel connection of 10 cells in 5 units of 2 cells each for use with 2 lamps connected in parallel, when cells are old, on a double observing party using tended lights

There will be 30 amperes and 5 volts in the lamp circuit, assuming an average of 15 amperes and 1 volt for each cell.

If both observers are almost in the same direction from your station, take such precautions as you can, with partitions of some material between the beams from the two lamps, to insure that each observer sees only the light of the lamp directed to him, and none from the other lamp.

In most cases the observers will make special arrangements with the light keepers in regard to showing heliotropes for a double observing party.

LIGHT KEEPER'S RECORD BOOK

Each light keeper shall keep a record book in which he shall enter an accurate account of the number of

cells, bulbs, etc., that he has received during the season and the number of hours they have been used. He shall also keep an account of the number of times his light, tended or posted as an automatic light, has failed to operate, with the reason for the failure. The book shall also contain a list of instruments and general property issued to the light keeper.

The purpose of this record is not to furnish a check on your work. The data accumulated in these books from year to year will be used for the guidance of parties in the future in the use of cells and bulbs and in the operation of the automatic lights. These books, or summaries of them, should be sent to the office by the chief of party at the end of the season in order that the information contained in them may be used by later parties. The sample which follows will give you an idea of what should be entered in the book.

SAMPLE PAGE OF LIGHT KEEPER'S RECORD BOOK

STATION BLACK, TEX., *April 15, 1925.*

Received the following:

Ammeter, No. 112	1
Axe	1
Binoculars, No. 214	1
Box, battery	1
Bulbs, extra, 0.6 ampere	2
Bulb, extra, 1.25 amperes	1
Cells, dry	10
Connectors, cell	10
Compass, No. 78	1
Cot, folding	1
Flashlight, No. 46	1
Hatchet	1
Lamp, signal, No. 225	1
Tarpaulin, battery	1
Tent, 7 by 7	1
Wire, feet	20

April 20.—No answer from "O" party; showed light 7.30–10 p. m.; 6 cells.

April 21.—3 hours, 6 cells.

April 22.—3 hours 20 minutes, 6 cells.

April 23.—2 hours 50 minutes, 6 cells.

April 24.—Replaced 0.6-ampere bulb, burned out by using 4 units after 20 minutes; 8 cells, 20 minutes; 6 cells, 3 hours 10 minutes.

April 27.—Started using automatic lamps; received 6 cells, 20 feet wire, 8 cell connectors, 1 lamp, 1 battery box, 2 extra bulbs 0.6 ampere, 1 extra bulb 1.25-ampere; used 12 cells 5 hours each.

May 8.—Light failed; clock stopped, needed winding.

May 21.—Light failed; cells short circuited in battery box on account of rain getting in box.

June 24.—Light failed to show; failed to open door on front of lamp.

ACCOUNTS

There are two kinds of accounts—"General accounts" and "Travel accounts."

Receipts must be taken for all expenditures except railroad fares and certain emergency expenditures such as phone calls on slot machines. Receipts to be included under "General accounts" (see below) are taken in the name of the chief of party; receipts to be included under "Travel accounts" are taken in your name to be entered later on a travel voucher (see p. 50) which must be sworn to.

General accounts include expenditures for express, freight, hire of team, hire of truck, and hire of man to assist in work; also charges for purchases such as oil, gasoline, axes, etc.

Travel accounts include railroad fares, excess baggage, and certain expenditures for which it is not practicable to obtain a receipt, such as telephone calls paid for by dropping a coin in a slot machine.

You are requested to make a special effort to follow the instructions below in the smallest detail, for by so doing you will avoid a great deal of correspondence, get your money sooner, and greatly simplify the matter of accounts for the chief of party. Study these instructions carefully and READ THEM OVER FREQUENTLY. There is little chance of making your work satisfactory until you know how to put into practice the details of these instructions.

GENERAL ACCOUNTS

The following directions are for making out receipts for general accounts:

1. Receipts must always give date and place.

2. Receipts must show purpose of expenditures, unless plainly evident.

3. Receipts should be made out in ink, if possible, and *must be signed* in ink or indelible pencil.

4. Make all explanations in writing on face of receipt.

5. Signatures by (X) are only to be made by persons unable to write their names. When made by (X), they must bear the name of the person and must be witnessed. (See sample of general subreceipt, p. 48.)

6. Do not lump items in receipts; they must be itemized.

7. Do not render receipts like this:

Cells, oil, and can $1.50

but make it:

2 cells at $0.40, $0.80; 1 gallon oil, $0.20; 1 oil can, $0.50.. $1.50

8. For hauling always give weight and distance or number of days team was employed, dates, and rates per day.

9. In sending telegrams to the chief of party mark "Official Government Message" and send it "Collect," and at the same time send a duplicate copy of the telegram by mail. Messages connected with the work and not addressed to the chief of party should be

marked "Official Government Business" and should be prepaid and a *Duplicate* taken, with the agent's receipt for the amount of money paid written on the face of the telegram. Government rates for telegrams are 40 per cent of commercial rates based on commercial count but with minimum charges, as follows: Full rate day message, 25 cents; night message, 20 cents; night letter, 30 cents; day letter, 45 cents. Always indicate on the duplicate the kind of message sent (one of the four just mentioned).

10. Receipts for phone calls must show points between which calls were made, number of minutes charged for, and how charge was computed, rate for overtime, etc. Where charges are paid by dropping coins in a slot machine, and it is not practicable to obtain a receipt, a travel voucher should be used. (See sample travel voucher, p. 50.)

11. Whenever an express bill is paid, obtain receipt from the agent for same and have indicated on the receipt the following seven things:

First. The name of the chief of party as payer.

Second. The place from which shipment was made.

Third. The place to which shipment was made.

Fourth. The weight of the shipment.

Fifth. The rate of the shipment per 100 pounds and scale number by which classified. The latter is very essential.

Sixth. The agent's signature in full and his title, under the name of the express company. The agent's signature by initials only is not sufficient.

Seventh. The method of packing, whether box, bundle, crate, or bale, and the contents of the shipment.

If you omit any of these, payment can not be made to you when the receipt is turned in. Be sure that the rate multiplied by the weight equals the charge, unless the weight is less than 100 pounds, when a graduated rate will apply. (See sample general receipt on p. 46.)

12. A receipt for supplies or services should not cover portions of two months. Use a separate receipt for each month.

13. Receipts signed by an employee of a firm, company, or corporation should be in the name thereof, and the full name and title (or occupation) of the person signing the receipt should be written below the name of the firm, company, or corporation, as:

Union Mercantile Co.,
Per John Smith,
Salesman

14. Your accounts are to be rendered on or immediately after the last day of each month and mailed to the chief of party with the least possible delay. The form of rendering accounts comes under two heads—

"Travel account" and "General account." They are to be kept distinctly separate. Sample forms of each are given in this pamphlet, with the necessary explanatory notes. In sending accounts to the chief of party state how many receipts are sent, the amount thereof, and make a statement showing the balance due you or the chief of party.

TRAVEL ACCOUNTS

The following directions are given in regard to travel accounts:

1. Travel receipts should be made out in the light keeper's name.

2. No receipt is necessary for railroad fare. Simply state on the travel voucher the amount paid, between what points, over what railroad, and the times of departure and arrival.

3. Travel receipts should be numbered 1, 2, 3, 4, etc., in the order of dates.

4. Receipts for excess baggage must show the number of pounds of excess, the points between which travel was made, and the charge per 100 pounds.

5. When telephone charges are paid by dropping coins in a slot machine, information should be given on the travel voucher similar to that given on telephone receipts, with an explanatory statement why receipt was not taken.

6. All expenditures for travel must appear on the travel voucher in the order of date, the travel voucher

to be sworn to by the light keeper individually. Any postmaster or the chief of party will administer the oath, and no charge can be made therefor. In case the oath is administered by a postmaster the space marked "L. S." on the voucher, in the space for the affidavit, should be stamped with the canceling stamp of that postoffice which shows the place at which oath was administered.

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT

$ 1.50 No. Newcastle, Wyo., June 4, 1921

Received of G. D. Cowie, in person, and IN CASH,

the sum of one Dollars and fifty Cents,

for express on outfit, Provo, S. Dak. to Newcastle, Wyo., 150 lbs. at $1.00 per hundred, packed in three boxes and two bundles (Scale No. ----) (The agent's receipt is just as good as the above, or even preferable, if all the necessary information is shown thereon)

*Witness: (To be signed here by express agent)

*ONLY SIGNATURES BY MARK (X) NEED BE WITNESSED. 11—3024

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 6
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT

$ 3.00 No. Newcastle, Wyo., June 9, 1921

Received of G. D. Cowie, in person, and IN CASH,

the sum of three Dollars and no Cents,

for stage fare for Jim Anderson, for 20 miles,	$2.00
Freight on 300 lbs at 33⅓ cents per hundred	1.00
	3.00

*Witness: (To be signed here by stage driver)

*ONLY SIGNATURES BY MARK (x) NEED BE WITNESSED.

11—3024

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1906)

MEMORANDUM SUBRECEIPT

$ 0.83 No. Newcastle, Wyo., June 10, 1921

Received of G. D. Cowie, *in person, and* IN CASH,

the sum of no *Dollars and* eighty-three *Cents,*

for express on one lot of batteries from Provo, S. Dak., to Newcastle, Wyo., 75 lbs at $1.00 per hundred, graduated rate (Scale No.-)

(The information shown on this receipt may be written on the face of the regular express receipt)

* *Witness:* (To be signed here by express agent):

* ONLY SIGNATURES BY MARK (X) NEED BE WITNESSED. 11—3024

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 21, 1908)

MEMORANDUM SUBRECEIPT

$13.00 No. Provo, S. Dak., June 2, 1921

Received of G. D. Cowie, in person, and IN CASH,

the sum of thirteen Dollars and no Cents,

for hire of team and driver for two days, June 1 and June 2, at $6.50 per day.

[This receipt should not be dated earlier than the last day for which charges are made]

*Witness: [To be signed here by man furnishing team]

*ONLY SIGNATURES BY MARK (x) NEED BE WITNESSED.

11—8034

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT

$ 8.00 No. Newcastle, Wyo., June 19, 1921

Received of G. D. Cowie, *in person, and* IN CASH,

the sum of eight *Dollars and* no *Cents,*

for labor for two days, June 18 and 19, at $4.00 per day

*Witness: (Signature of witness)

Pete Hie X Crow
~~Mark~~

*ONLY SIGNATURES BY MARK (X) NEED BE WITNESSED.

11—3024

[Sample—General]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 8
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT

$ 2.42 No: Provo, S. Dak., June 1, 1921

Received of G. D. Cowie, in person, and IN CASH,

the sum of two Dollars and forty-two Cents,

for 2 lbs of nails at .06 $ .12

1 axe 1.50

2 batteries at .40 .80

2.42

*Witness: (To be signed here by salesman)

*ONLY SIGNATURES BY MARK (x) NEED BE WITNESSED.

11—3054

[Sample—Travel]

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT

$ 1.00 No. Newcastle, Wyo., June 4, 1921

Received of Jim Anderson, in person, and IN CASH,
the sum of one Dollars and no Cents,
for excess baggage on 100 lbs. baggage, Provo, S. Dak., to
Newcastle, Wyo., at $1.00 per hundred

*Witness: (To be signed here by baggage agent)

*ONLY SIGNATURES BY MARK (X) NEED BE WITNESSED.

11—9034

[Sample—Travel voucher (page 1)]

DEPARTMENT OF COMMERCE.
U. S. COAST AND GEODETIC SURVEY.
Form 4.

VOUCHER FOR REIMBURSEMENT OF TRAVELING EXPENSES.
(Form approved by the Comptroller of the Treasury June 5, 1918.)

Note General Instructions on back of Voucher.

The United States,

To Anderson, Jim (Name of payee.), Dr.

Address: U.S. Coast and Geodetic Survey (Street and number.), Newcastle (City or town.), Wyoming (State.)

For REIMBURSEMENT of traveling expenses, per schedule annexed, incurred in the discharge of official duty from June 1 (first day of mo.), 1921, to June 30 (last day of mo.), 1921, under written authorization from the Director, dated ....., 19...., a copy of which is attached hereto and forms a part of this account.	DOLLARS.	CTS.
AMOUNT CLAIMED.....	2	80

(Bill must be completely made out before any certification, and there must be no alteration or erasure.)

OATH OR AFFIRMATION OF CLAIMANT.

I do solemnly *swear that the above account and annexed schedule are just and true in all respects, as verified by a memorandum kept by me; that the distances as charged have been actually and necessarily traveled on the dates therein specified; that the amounts as charged have been actually paid by me for traveling expenses; that I have not and will not receive, directly or indirectly, from any person, agency, or corporation any sums as rebate on account of any expense of transportation included in this account; that none of such distances for which charge is made was traveled under any free pass on any conveyance; that no part of the account has been paid by the United States, but the full amount is justly due; that all expenditures included in said account other than my own personal traveling expenses were made under urgent or unforeseen public necessity, and that it was not, for the reasons stated herein, feasible to have payment made for such expenditures by the Disbursing Agent of the Coast and Geodetic Survey. SO HELP ME GOD.

(Signature.) Jim Anderson

(Official title.) Hand, U.S.C. and G. Survey.

L. S.

Subscribed and †sworn to before me at Newcastle, Wyo., this 30th day of June, 1921.

[Signed) John Doe

(Title.) Postmaster

My commission expires ....., 19.....

I CERTIFY that the above account is correct and just; that I have examined the same and believe the expenses were necessarily incurred and paid as therein stated. Chargeable to appropriation—

"....."

and approved for $ [redacted] (Differences, if any, shown inside.)

.....

(Title.) .....

(Receipt to be signed only in case of payment in cash.)

Received of G. D. Cowie in person, or by his deputy, and in cash, the sum of Two dollars and 80 cents, in full payment of the above account, which I certify to be correct.

$ 2.80 (NOT to be signed in duplicate.) Jim Anderson

Paid by Check No. ....., dated ....., 19....., for $....., drawn on the Treasurer of the United States, to order of Payee named above.

*Swear or affirm. †Sworn or affirmed. 11—611

16203—26. (Face p. 50.)

(OVER)

[Sample—Travel voucher (page 2)]

SCHEDULE of Traveling Expenses—and Other Expenses incurred under stress of urgent or unforeseen public necessity.

DATE.			SUB-VOUCHER No.—	AMOUNT	
				DOLLS.	CTS.
1921.		☞ Fill in form on this voucher showing how transportation requests were used.			
June	4	Excess baggage, Provo, S. Dak., to Newcastle, Wyo., 100 lbs at $1.00 per hundred	1	1	00
"	4	Railroad fare, Provo, S. Dak., to Newcastle, Wyo., about 50 miles		1	80
		Left Provo 8:05 A.M., arrived Newcastle 10:20 A.M.			
		AMOUNT CARRIED FORWARD			

NOTE.—The date and hour of boarding and leaving trains MUST be stated in each instance.

11—611

16203—26. (Face p. 50.)

[Sample—Transmitting letter of monthly accounts]

Newcastle, Wyo., June 30, 1921

Mr. G. D. Cowie
Chief of Party, C. and G. Survey
Sir:
Enclosed please find six general receipts aggregating $28.75
Also find enclosed my June travel voucher 2.80
Total 31.55

Amount due chief of party June 1 3.15
Advances by chief of party during June 30.00
Total advances 33.15
Expenditures as above 31.55
Balance due chief of party June 30 1.60

Respectfully
(Sign here)

At the end of each month the lightkeeper shall signal to the chief of party the total amount of his expenditures for the month just closed, as for example: Expenditures June $31.55.

Note to chief of party.

Any lightkeeper's current month's account of expenditures from funds previously furnished him, not received by you and included in your accounts for that month, shall (upon the amount thereof being signalled to you by the lightkeeper as above instructed) be reported in that month's Statement of Accounts in the "Analysis of Balance" as "Payment made and claim for credit deferred".

APPENDIX

WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

In order that the light keeper may understand something of the general nature of the work of the party and be able to answer the questions of interested persons, the definition of a geodetic survey and a brief description of triangulation as carried on by the United States Coast and Geodetic Survey are here inserted.

A GEODETIC SURVEY—WHAT IT IS

The question most frequently asked our field parties is "What does the word 'geodetic' mean and what is a geodetic survey?" The question is a natural one, for geodetic (pronounced gee'-o-det'-ic, with the g sounded as in gem) surveys are much less frequently encountered than some other kinds.

A geodetic survey is one which takes into account the fact that the earth has a curved surface. Most geodetic surveys are for the purpose of supplying starting points for local surveys and are therefore often called control surveys. These control surveys must be made with the greatest accuracy, and since they must extend over the entire area of a country they must be corrected for the curvature of the earth's surface, which is not uniform.

A geodetic survey party may be engaged in any one of a number of operations, such as triangulation, traverse, leveling, astronomical observations, or measurements of the intensity of gravity.

FIRST-ORDER TRIANGULATION

In order to avoid the gaps, overlaps, and offsets which are always found when independent local surveys are joined together, it is necessary to locate a system of points with the distances and directions between them accurately known. To determine these distances by direct measurement would be very expensive, and therefore recourse is had to triangulation.

The triangulation method involves selecting a series of points over the area to be surveyed, each point being visible from certain of the adjacent points. The distance between two of these points, called a base line, is then measured with an average accuracy represented by an error of about one-quarter of an inch to the mile. If the observer then measures the angles in the triangle formed by the stations at the ends of the base line and a third point visible from the ends of the base, the distances of the third point from the two ends of the base can be easily computed, and by measuring the angles at other stations, selected to form a system of triangles with the first triangle, the distances between each pair of stations can be computed from the measured length of one base line.

One other step is needed before a survey based upon triangulation can be fitted into its correct place in the map of the country, and that is to connect the survey with two or more points whose latitude and longitude are known. This is done by including in the triangulation two or more stations of the first-order triangulation of the Coast and Geodetic Survey which traverses the country in belts several hundred miles apart. A survey so connected is said to be on the North American Datum, for the first-order triangulation of the United States, Canada, and Mexico are all on the same datum; that is, are all joined together in one great system.

The advantages of such a connection are manifold. Local surveys and engineering projects can be shown in proper relation to those adjoining. Roads, railroads, canals, and power projects can be more economically planned and located because existing surveys can be better used. Land boundaries connected to such a triangulation scheme are sure of perpetuation, for even though the boundary marks and the adjacent triangulation stations were destroyed, both could be restored by triangulating from more distant marks. In some countries and States, as in the State of Massachusetts, property corners are so connected, and the boundaries are described in terms of latitude and longitude as well as by distances and directions.

It is readily seen that the inscribed tablets set in concrete or rock, which are left by the survey party

to mark the stations, are of great value to the community, for it is to them that local surveys must be connected. Those living near the stations are earnestly solicited to assist in preserving these tablets from disturbance by informing others of their value as survey marks.

A description of the methods used by triangulation parties may be of interest. The first operation, called reconnaissance, consists of selecting the locations for the stations, testing out to see if adjacent stations are intervisible, and securing information as to the best routes by which the stations can be reached. The next operation is to mark the stations with tablets set in stone or concrete and to build the rough wooden tripods, usually about 4 feet high, on which will be set the theodolite with which the angles are measured. Sometimes tall towers must be built to raise the instrument above intervening trees or hills, and when such is the case each tower consists of two structures entirely separate from each other, an inner tripod on which the theodolite is placed and an outer four-sided scaffold supporting a platform on which the observer stands in order that his movements will not disturb the theodolite.

The stands or towers being built, everything is now ready for the observing party, which consists of the observer and two or three assistants on the observing party proper and of six or seven light keepers. Observations to determine the approximate difference

of elevation of the various stations are made in the afternoon, but all measurements of horizontal angles by which the distances between stations are computed are made at night.

The instrument called a theodolite, which is used to measure the angles, is somewhat like a surveyor's transit in principle but much more accurate. It is equipped with micrometer microscopes, which enable the observer to make a single reading of an angle to the nearest second of arc, while an ordinary transit can be read for a single measure of an angle to the nearest 30 seconds only. An angle of 1 second can be best visualized by remembering that if the telescope of a theodolite is pointed exactly on a target 40 miles away and the reading of the circle is then changed by 1 second the telescope will point to a spot 1 foot to one side of the center of the target.

Since the points to be observed upon are often 50 miles or more distant from the observer, the following method is used to make them visible: A light keeper is posted at each station to be observed upon. During the afternoon he shows a heliotrope to the observer's station and at night a specially constructed electric light run by dry cells. The heliotrope is an arrangement for directing toward any desired point the sunlight reflected from a plane mirror. A heliotrope has been observed upon from a distance of 190 miles and an electric lamp from 153 miles, but this was in desert regions, where the atmosphere was clear. When the

observer has completed his measurements upon a light, he signals the light keeper in code, by dots and dashes of his own light, and tells him where to show his light next.

In recent years automatic signal lamps have been used at times with great success. These lamps are governed by an eight-day clock which turns on the light at a definite time each night and turns it off again after an interval of time, usually three or four hours, has elapsed. With automatic lamps only two light keepers are required, each operating a truck, one to post lamps ahead of the observing party and the other to post lamps at the rear stations. The lamps have a very small beam and must be accurately pointed to enable the observer to see the light.

A warning notice is usually tacked on the stand, requesting visitors not to interfere with the adjustment or the pointing of the lamp. The total cost of a triangulation party may run as high as $75 per day, and a thoughtless turning of a lamp by some visitor to the station might easily cost the Government two or three-hundred dollars by delaying the progress of the party.

OTHER ACTIVITIES

The work of the bureau embraces a great many other operations besides first-order triangulation. For the general information of the light keeper and to help him answer some of the innumerable questions which are always asked him regarding the survey and its work,

some of its principal functions are briefly mentioned below. Those who desire a more detailed account will find it in Special Publication No. 23, the United States Coast and Geodetic Survey, description of Its Work, Methods and Organization, which can be obtained free of charge by application to the Director, United States Coast and Geodetic Survey, Washington, D. C.

A full and complete knowledge of the coast, including its nature and form, the character of the sea bottom near it, the location of reefs, shoals, and other dangers to navigation, the rise and fall of the tides, the direction and strength of the currents, and the character and amount of magnetic disturbance, is of the greatest practical value to all nations whose territories touch the sea or who have any interests in the commerce of the sea.

To supply this knowledge the Governments of the principal maritime nations have in modern times made surveys of their coasts by the most exact methods, and it was for this purpose that the United States Coast Survey was organized more than a hundred years ago. In 1871 the scope of the bureau's work was enlarged to include the determination of geographic positions and other data for the surveys of the interior States, and in 1878 its designation was changed to "The Coast and Geodetic Survey." The word "geodetic" refers to the various operations and investigations in which the curvature of the earth's surface is taken into account, instead of being ignored as in ordinary surveying, where

parts of the earth's surface having equal elevation are treated as plane.

To-day the work of charting the 100,000 miles of detailed shore line and adjacent waters of the United States and its possessions is being carried on by the 10 or 12 steamships operated by the bureau and by various launch and shore parties. The depths of water and the character of the bottom are ascertained by the lead line, either the hand lead or the lead line of a sounding machine. In depths up to 20 fathoms the hand lead is used. This consists simply of a piece of lead, somewhat in the shape of a window weight, attached to a marked cord, and is thrown by a leadsman from a sounding platform in the bow of the boat. With a sounding machine the lead is attached to a wire wound upon a reel, which may be either hand or steam operated, the wire passing over a device which registers on a dial the length of wire run out. In very deep water the lead is detachable and after a sounding the wire only is reeled in, except that there are at the end of the wire a thermometer and other small instruments and an attachment for bringing up a specimen of the bottom. The depths of water so determined are afterwards shown on a nautical chart in their proper relation to the shore line and to the parallels and meridians. Lighthouses, buoys, and all topographic features which may aid the mariner are also indicated in their proper location on the chart by means of symbols.

Where there are numerous submerged ledges and pinnacle rocks in the waters traversed by ships, the lead line will not always disclose these dangers. Before it can be said with certainty that a given region is safe for shipping it must be examined with a wire drag. This is a wire suspended horizontally in the water at any desired depth by means of vertical wires leading up to buoys at the surface. This drag may vary in length from a few hundred feet to more than 4 miles and is towed through the water by launches so as to sweep the area to be examined at the depth at which the horizontal wire is set. Whenever an obstruction projects above that depth, whether it be a rock, sand bar, or submerged wreck, the horizontal wire catches upon it or is lifted by it, and the location of the danger is indicated by the buoys from which the horizontal wire is suspended.

As a basis for State surveys and to serve in the accurate location of national, State, and county boundaries, and as a foundation for other Government surveys and for map makers and surveyors, the latitudes and longitudes of a network of points over the entire country must be determined, together with the distances and directions between them. (A more detailed account of the purposes and methods of first-order triangulation is given on pp. 53–57.) This the Coast and Geodetic Survey does by extending its first-order triangulation into all parts of the country as rapidly as facilities are provided. Connected with

this are other geodetic operations, such as star observations for latitude, longitude, and azimuth, and the swinging of pendulums to measure the force of gravity. The bureau also has fixed observatories where measurements are made of the variation of latitude at that place caused by a slight wobbling of the earth as it rotates on its axis.

The engineer or surveyor is not content to know simply the latitude and longitude of a place; he needs to know also its elevation above sea level. The first-order leveling of the Coast and Geodetic Survey extends along many of the principal railway lines of the country, and the bench marks established serve as a basis for any further leveling done in their respective localities.

Both the navigator at sea and the surveyor ashore need to know the magnetic declination or the amount the compass north varies from the true north. For instance, in the northeastern part of Maine the magnetic needle points 22° west of north, while in the northwestern part of the State of Washington it points 25° east of north, a difference of 47° within the limits of the United States. Moreover, the angle between the compass and the true meridan is constantly changing. Even in the course of a day, from 8 in the morning until 2 in the afternoon, the needle changes its direction by an amount sufficient to be taken into account. This change may cause a discrepancy at the end of a line a mile long, run by the compass in the

morning and rerun in the afternoon, amounting to from 5 to 20 feet, according to the season of the year. To determine the amount and rate of change of the declination of the compass, as well as the inclination and intensity of the magnetic force, a great number of observations are made annually by the survey, either at fixed observatories in the United States, Porto Rico, Alaska, and Hawaii, or by special parties sent out to different parts of the country. Sometimes the various field parties of the bureau, on sea and on land, make magnetic observations as an adjunct to their regular surveying work.

The principal publications of the survey consist of about 670 different charts, covering all the coasts of the United States and its outlying insular possessions; annual tide tables for all the principal and many of the minor ports of the world, the most comprehensive volumes of this class issued by any country; Coast Pilots, containing sailing directions for all navigable waters along our coast; special publications which give, in a form suitable for use by surveyors and engineers, the geographic positions and descriptions of triangulation stations, the elevations and descriptions of first-order leveling bench marks, and data for the magnetic stations; the annual report of the director on the conduct of the work; and special reports upon the various technical and scientific operations of the service.

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