# USE OF WIRELESS TELEGRAPHY IN LONGITUDE DETERMINATION

In accordance with a request contained in International Hydrographic Bureau Circular-Letter 23-H, 1927, the Hydrographer of the U. S. Navy has sent to the Bureau information obtained from the Commanding Officer of the U. S. S. *Niagara*, the only U. S. vessel at present engaged in longitude determination, and from the Superintendent of the Naval Observatory, Washington.

The information is as follows :

1°) *FROM U.S.S. " NIAGARA ".*

*I.* In the survey carried on in VENEZUELAN and COLOMBIAN waters by the U. S. S. *Niagara* during the season of 1926 a long wave receiver manufactured by Bureau of Engineering, Navy Department, type *SE*-1899, was used. In the first station established at Zapara Island, Venezuela, the time ticks from Annapolis, Maryland, were obtained on several successive nights. In obtaining these ticks the observing officer listened in on the ticks with a key attached to a chronograph, manufactured by QUEEN & C°. and furnished by the U. S. Naval Observatory, which was in turn connected to a mean time chronometer with a make and break connection. As the tick came in, the observer pressed his key thus registering on the chronograph the time of the tick. The same evening, if possible, a set of observations of time stars, two sets of five each, were taken in order to obtain the correction of the mean time chronometer on local mean time. In taking the ticks each of the minutes in the set was registered thus reducing the error of the observer to a minimum and the mean of all these values taken. The instrument used in taking the time sights was a Stackpole transit as furnished by the U. S. Naval Observatory.

*II.* At the second station established, at Castilletes, Venezuela, the long wave receiver broke down and this brought up the necessity of makeshift arrangement which did not prove very successful. This arrangement consisted of having the ship receive the time ticks on its own set and rebroadcast these ticks to the station where they were received on an Army field set used in communicating with the ship, in a similar method to that described above The main disadvantage was due to the fact that there were too many chances of error such as lag in receiving on the ship, lag in sending from the ship and lag in receiving at the station; of course, these errors would be multiplied as it went through each step.

*Signed :* G. M. BAUM.

## 2°) *FROM THE U.S. NAVAL OBSERVATORY, WASHINGTON.*

The methods used by the Naval Observatory are adapted for use at a fixed observatory, and some of them would hardly be practicable in field work. The Naval Observatory has aimed at the following points :-

*The elimination of collimation error* of the transit instrument used for time determination, and also the effect of inequality of pivots, by reversal on each star at each observation. The instrument was made by PRIN, of Paris, and permits this to be done easily.

*The elimination of the effect of varying azimuth* of the transit instrument, which in our experience is sometimes very considerable, by the use of a meridian mark upon which a set of readings is made near the transit time of each star. The azimuth of the mark is determined by reference to pole star observations.

*The selection of time stars transiting near the zenith,* balanced north and south of zenith, to reduce the effect of azimuth error.

*The evaluation of the spirit level division value* during the work by the use of a level trier without removing the level from the mounting in which it is used. Also vertification of the spirit level determinations, by nadir level observations.

*The determination of personal equations* of transit observers by special apparatus used in connection with the long focus (50 metres) meridian mark lens. Also the use of the impersonal self-registering transit micrometer, by which personal equations are usually made very small. The PRIN instrument has the self-registering micrometer operated by an electric motor. The speed is variable and is set for each star, and the fine motion of adjustment is by a milled head operating through planetary gear.

*The elimination of the effects of all lags* as far as possible by having the radio signals, the clock ticks, and the transit observer's signals all registered on the same chronograph, using the same electro-motive force for all. It has been found necessary to have one intervening relay, between the radio receiving set and the chronograph, whose lag affected the result, and for whose effect a correction was necessary. This lag was measured and investigated and found to be a function of the amount of current coming from the radio to the primary of the relay. This current was indicated by an ammeter in the circuit. The reading of the ammeter was recorded for each radio set observed, and was used as the argument for obtaining the correction. In the recent world longitude work these corrections varied from $0^s,01$ to $0^s,06$, usually being about $0^s,03$. Since then the relay has been improved, and the lag now is usually less than $0^s,005$.

*The elimination of lags* is considered to be one of the most important matters in connection with radio longitude work.

*Signed :* EDWIN T. POLLOCK.

The following are Instructions for Constructing Apparatus for Receiving and Recording Radio Time Signals, prepared and distributed by the U. S. Naval Observatory, Washington, D. C.

## INSTRUCTIONS FOR CONSTRUCTING APPARATUS FOR RECEIVING AND RECORDING RADIO TIME SIGNALS.

### *GENERAL.*

In order to make a graphic record of radio time signals it is necessary to have means of receiving and detecting the signals, and also apparatus for amplifying and recording these signals.

During the coming world longitude determination, time signals are to be sent out on low radio frequencies of less than 60 kilocycles (wavelength more than 5000 metres) and also on high frequencies of more than 3000 kilocycles (wavelength less than 100 metres). It is not practical to use the same type of receiver for both frequency bands, but the same amplifier and recorder may be used with either receiver. There is, therefore, described herewith (1) a low frequency receiver, (2) a high frequency receiver, and (3) an amplifier and relay unit. It will probably be sufficient to receive either the high or the low frequency signals in order to connect secondary longitude stations in the fundamental polygon.

In case an observatory already possesses receiving apparatus sufficiently sensitive and which has the required selectivity, it may be used. But if it is necessary to construct equipment, it will be found that the high frequency (short wavelength) receiver is the cheaper and easier to construct, and can be operated with less difficulty.

The night signals on high frequency can be received all over the continental United States. Such signals sent out from Washington at about 6.00 A. M. have been recevied in almost all parts of the Pacific and the far east. When signals must be received through daylight, however, low frequency is preferable, if not absolutely necessary.

Makes of parts specified below are such as have been actually used at the U. S. Naval Observatory. While other makes may often be successfully substituted, it must be remembered that different makes of transformers, tubes, and other apparatus have very different characteristics, and in complicated arrangements such substitution may prove a cause of failure.

### *LOW RADIO FREQUENCY RECEIVER.*

The parts shown in fig. 1. are as follows : (Letters refer to drawings).

*A.* Primary tuner. This is shown connected to a loop collector. The loop is more selective than an ordinary antenna, and it should consist of about 40 turns, 8 feet square, spaced one inch between turns. A variable condenser of not less than 0.002 microfarads capacity should be used. The inductance of the coil should be about 55 millihenries for use with the loop and 0.002 microfarad condenser. A smaller coil will serve with a larger condenser ; a much larger one will be required with an ordinary antenna unless the tuning condenser is placed in shunt with the coil. In order to secure selectivity the coupling between *A* and *B* must be very loose. Provision must be made for rotating the inductance *A* so that it will be about two or three inches distant from *B* at the nearest point, and so that their magnetic fields neutralize in one position. That is, mount coil *B* in a fixed horizontal position, and mount coil *A* so that its center lies on the axis of coil *B*, and so that it may be rotated to horizontal or vertical. Do not place one coil inside the other.

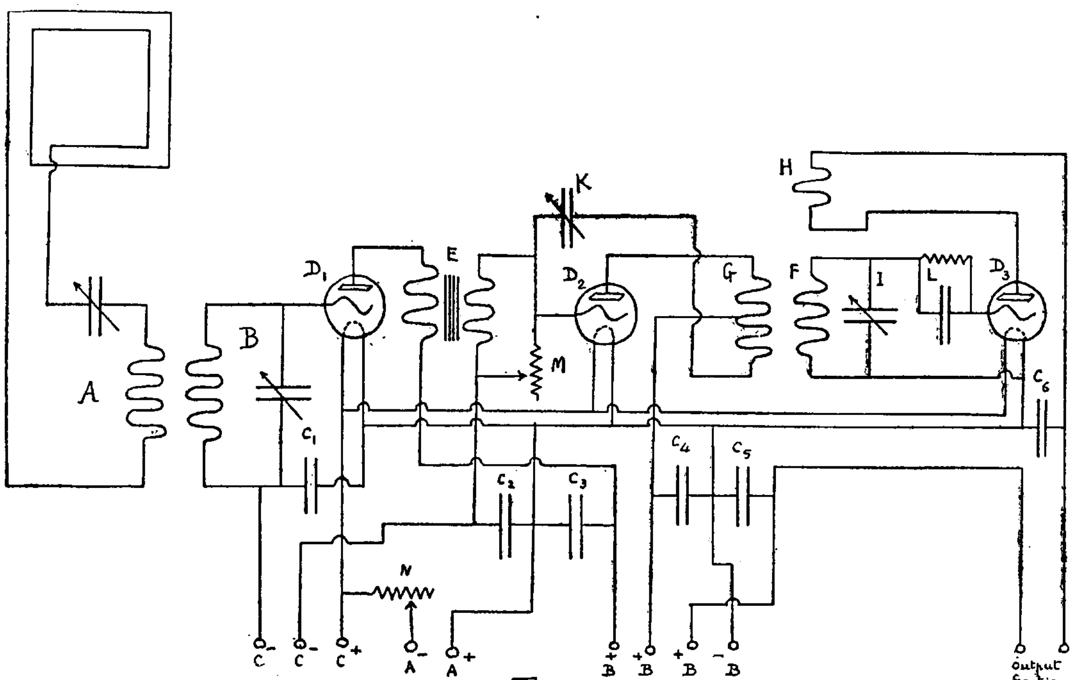


Fig. 1

Slight rotation from the neutral point will usually give sufficient coupling. In making the inductance the requirements discussed under *B* must be followed.

*B*. Grid or secondary tuner. The size of the condenser and coil should be about the same as specified under *A*. The condenser should be of low loss construction. Those in use at the Naval Observatory are manufactured by the General Radio Corporation, Cambridge, Mass. The *B* condenser should be at least 6 inches from the *A* condenser. A low ratio slow motion dial will be advantageous. The filament connections should be connected to the rotor and the grid connections to the stator. The stator plates of the condenser should be shielded from the hand of the operator. In order to obtain selective reception the tuning coils must be made of litzendraht wire, *i.e.* wire made of a number of insulated strands. It is recommended that 48 strands of N° 38 enameled wire be used. The coils should be bank wound, using nothing but collodion, unless specially prepared varnish, and means of baking the coils are at hand. Description of bank winding is to be found in Circular of the Bureau of Standards N° 74. The tuning circuits *A* and *B* should preferably be mounted in a cabinet separate from the rest of the apparatus, and it is probably advisable for the novice not to attempt to shield them.

*C*1, *C*2, *C*3, *C*4, *C*5. Paper condensers, 2 microfarad capacity. Only high grade condensers should be used. *C*6 should be a 0.0005 microfarad mica condenser.

*D*2, *D*1, *D*3. Vacuum tubes. Radiotron *UV*2013 or *UX*201*A*.

*E*. Iron core radio frequency transformer. Those in use at the Naval Observatory are specially built, but the Radio Corporation transformer *UV*1716 is satisfactory. This transformer can be obtained from the Radio Surplus Corporation, 11 to 19 Stuart St., Boston, Mass.

*F*. Tuned inductance. This may be wound with solid wire of small size (about N°32) as low losses are not important. It should be capable of resonance at 15 kilocycles when tuned with condenser I under actual operating conditions. It will probably be necessary to determine actual value by trial.

*G*. Inductance having about two thirds as many turns as *F*, closely coupled to *F*, and with tap in center.

*H*. One coil having about half as many turns as *F*, capable of variable coupling with respect to *F*, and controlled from outside of cabinet. It is suggested that coils *F* and *G* be wound in slots in pancake form, side by side with a sheet of bakelite between them, and that coil *H* be mounted on the opposite side of *F* from *G*.

*I*. Variable condenser, 0.002 mf. capacity.

*K*. Small variable neutralizing condenser. This may be set to a permanent value and need not be operated from the front of the panel.

*L*. Mica condenser, 0.00025 microfarad, with a 5 megohm grid leak.

*M*. "Centralab" 0-2000 ohm variable resistor, made by the Central Radio Laboratories, Milwaukee, Wis.

*N*. Rheostat, 7 to 10 ohms.

Excepting for the input tuning units *A* and *B*, all parts should be enclosed in a shield of brass, copper or aluminum not less than 1/16 inch thick, with a metal partition completely separating the last tube (*D*3) and its tuning coils from the first tube. No opening should be made in the shield, except the smallest holes through which the connections can be correctly made. The shield should be connected to the plus of the filament lighting battery. Make the wires to plate and grid connections of all tubes as short as possible.

To operate place about 33 volts *B* battery and 4 ½ volts *C* battery on the first tube, and about 22 ½ volts *B* battery on the second and third tubes. After the set is in operation these values may be changed if improved reception results therefrom. Connect the output of the receiver to the amplifier described in the next section, and listen in with the phones connected to that instrument. Reduce the resistance *M* to about one fourth its total value, and then set *K* so that no squeal is heard when the last tube is allowed to go into oscillation by manipulating *H*. A slight pop will be heard when the detector begins to oscillate. Then increase the resistance *M*, if necessary reset *K*, and repeat the process until *K* is at the best value for preventing the set from squealing. When this is accomplished set the coupling between *A* and *B* at a medium value (Set coil *A* at about a 60° angle with respect to *B*), then operate the condensers of *A* and *B*, and condenser I and coil *H* until a station is heard. Then reduce the coupling between *H* and *F* as much as possible, reduce the coupling between *A* and *B* returning *A* and *B* if necessary, and finally increase resistance *M* as much as possible without causing instability. *M* should always be kept at the highest stable value.

*HIGH FREQUENCY RECEIVER*·

Figure 2 is a schematic wiring diagram of the high frequency tuner. It may be used in connection with almost any type of antenna. The units shown in the drawing are as follows: (Letters refer to drawing).

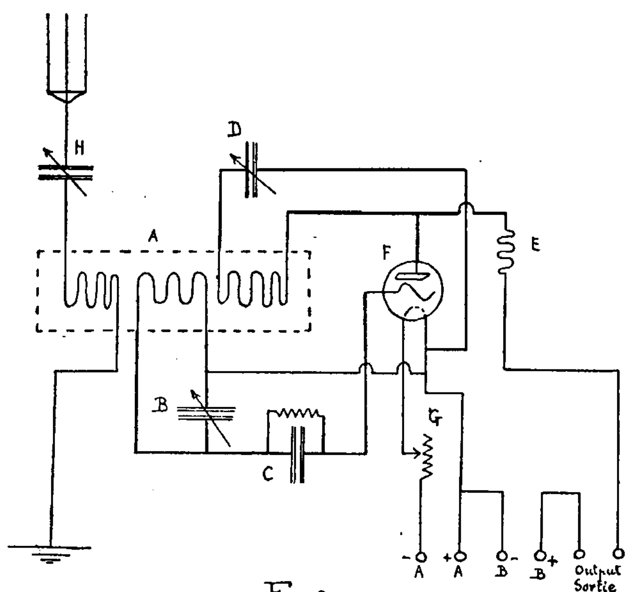


Fig. 2

6.—

*A.* The part of the drawing surrounded by the dotted line consists of an antenna coil, grid coil, and a tickler coil. In order to cover a very wide frequency band, it is advisable to use interchangeable coils, which may be plugged in and out. The grid coils should be space wound, preferably of N° 16 or N° 18 copper wire, and should have a minimum of solid dielectric material in their field. Several coils are on the market made up for the purpose. Those made by the Aero Products, Inc., 1768-1772 Wilson Ave., Chicago, Ill., have been tested at the Naval Observatory, and found satisfactory.

*B.* Low loss, straight line frequency, variable condenser with shielding between stator plates and panel. For use with the make of coils referred to above, the condenser should have a capacity of 0.00014 mf. A condenser of larger capacity can be used by cutting away part of the stator plates. The following makes of condensers have been found satisfactory:

Hammerlund S.L.F.
Karas Orthometric.
Cardwell Taper Plate.

It is necessary that the condenser be operated by a slow motion dial, as the tuning is very critical. A friction drive dial with easy motion is most satisfactory. If the condenser has friction in its motion it should be relieved so that it runs quite free.

*C.* Mica Condenser and grid leak. These are very important, and it is well to provide clips so that various grid condensers and leaks may be tried. The condenser should be from 0.0001 to 0.00025 microfarads, and the grid leak from 4 to 9 megohms. Good grid leaks are hard to secure. Poor ones may produce noise in the receiver. Use the smallest condenser and highest value of grid leak with which the apparatus may be operated without howling.

*D.* Variable condenser for controlling regeneration. The rotor of the condenser should be connected to the filament. Shielding should be provided to prevent capacity effects between the hand of the operator and the stator plates of the condenser. The proper value for the condenser is 0.00025 to 0.0005 microfarad.

*E.* High frequency choke coil, 200 turns of N° 30 wire wound on a one inch tube.

*F.* Radiotron tube *UX*201*A*. Use a base with no metal shell.

*G.* Filament rheostat (10 ohms).

*H.* An antenna condenser is sometimes useful, but not always necessary.

*It is very important* that all connecting wires be as short as possible and free from other wires. The wires which are shown heavy in the diagram should be made short, and should pass where they will be as far as possible from solid dielectric and from other wires. The receiver should be designed with this in view. The tuning coils should have two inches of free space all around, and no large conductors (except, perhaps, the tuning condenser) within several inches. Experience will show the proper setting of the antenna coil and once being set it will not need much change. Operate the tube just on the point of oscillation. It is best to call in an experienced amateur to adjust the set, if the maker is inexperienced.

### *AMPLIFIER AND RELAY UNIT.*

The parts shown in Figure 3 are as follows: (Letters refer to drawing).

*A.* "Centralab" resistance 500000 ohms, made by Central Radio Laboratories, Milwaukee, Wis.

*B.* Rheostat 7 ohms.

*C*1, *C*2, *C*3, *C*4, *C*5. Paper Condensers, 2 microfarads capacity.

*D.* Audio transformer. General Radio Company Type 285, 6 to 1 ratio, manufactured by the General Radio C°., Cambridge, Mass.

*E.* Audio transformer. General Radio C°. Type 285, 2 to 1 ratio.

*F.* Audio transformer, Acme A2, Old Style, manufactured by the Acme Apparatus C°., Cambridge, Mass.

*G,H.* Radiotrons *UV*201*A* or *UX*201*A*.

*I.* Radiotron *UX*112 or Western Electric *VT*2. If the *VT*2 is used connect negative end of the filament direct to 6 volt battery, not to rheostat.

*K* Ordinary small, pony type telegraph relay, wound with N° 40 enameled wire. It is important to wind as much wire on as possible, and to exercise care in soldering leads. Relay

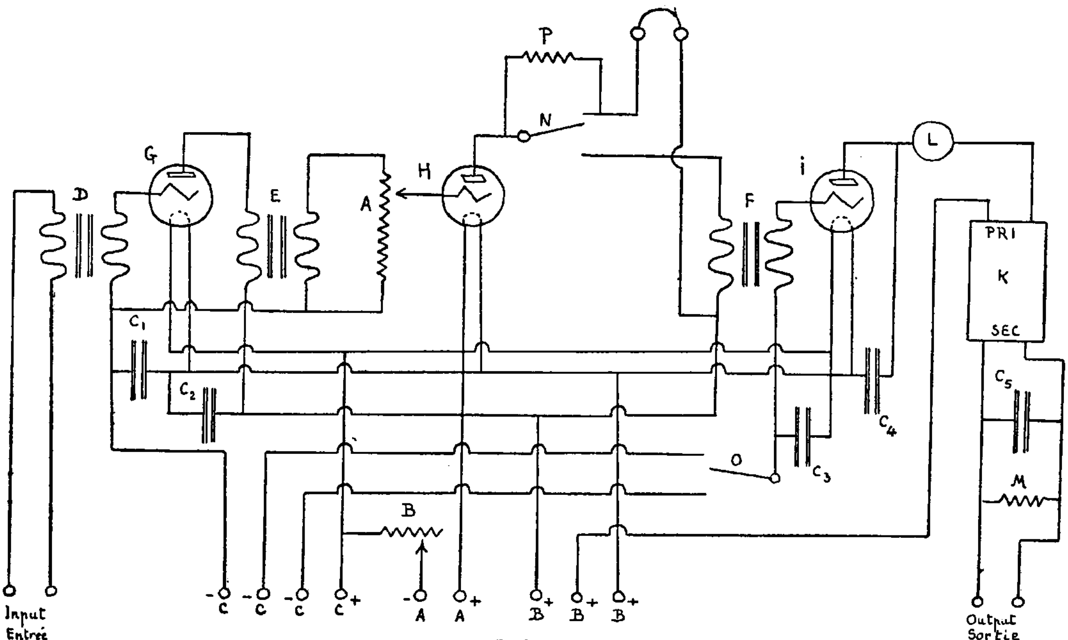


Fig. 3

gate should be adjusted to move through a very small distance (0.01 inch) and set as close to the end of the magnet core as possible without danger of hitting.

*L.* Milliameter, range 0-15 milliamperes. A small range may be used by placing a shunt resistance in parallel with it.

*M.* Fixed, non-inductive, resistance to prevent sparking. About 2000 ohms is satisfactory.

*N.O.* Single pole double throw switches.

*P.* Resistance, 1 ½ megohms. An ordinary grid leak resistor may be used.

All parts should be enclosed in a shield of brass, copper, or aluminum not less than 1/16 inch thick, and with a metal partition completely separating the last or recording tube and its input transformer (*F*) from the other tubes. No openings should be made, except the smallest holes through which the connections can be properly made. The shield should be connected to the plus of the filament lighting battery.

The same batteries may be connected to the recorder and the receiver. Use about 45 volts *B* battery and 4 ½ volts *C* battery on the first two tubes. On the last tube there are two optional *C* battery connections, controlled by the switch *O*. Use about 40 and 80 volts on these. The *B* battery on this tube should be 135 to 200 volts.

To operate turn the switch *N* to put the energy all on the head phones. Set the resisttance arm *A* so that the grid of the tube *H* is connected directly to the output of the transformer *E*. When signals are heard turn switch *N* to put energy on last tube. Sufficient power will still leak to the phones through resistance *P* to make the signal audible. If signals operate the relay too strongly, or if it is desired to cut out interference which is of less intensity than the signal, the resistance *A* is adjusted to a proper value. It is recommended that the relay be adjusted to break the chronograph circuit when the signal comes in, as this will result in less lag in the recorder. It is important that the relay have good pivots, so that there will be no rattle or lost motion at the lower end of the armature. It has been found, at the Naval Observatory, that if the spring tension is adjusted so that it just balances the magnetic pull when 3 milliamperes are flowing through the coils, the lag of the relay is fairly uniform for currents of 7 milliamperes and over. This lag appears to amount to almost two hundredths of a second when the recorder is used with a low frequency receiver. Part of this lag probably occurs in the receiver (tuner and radio amplifier). In order to secure uniform lag the relay should be carefully wound and correctly adjusted as suggested above under description of relay.

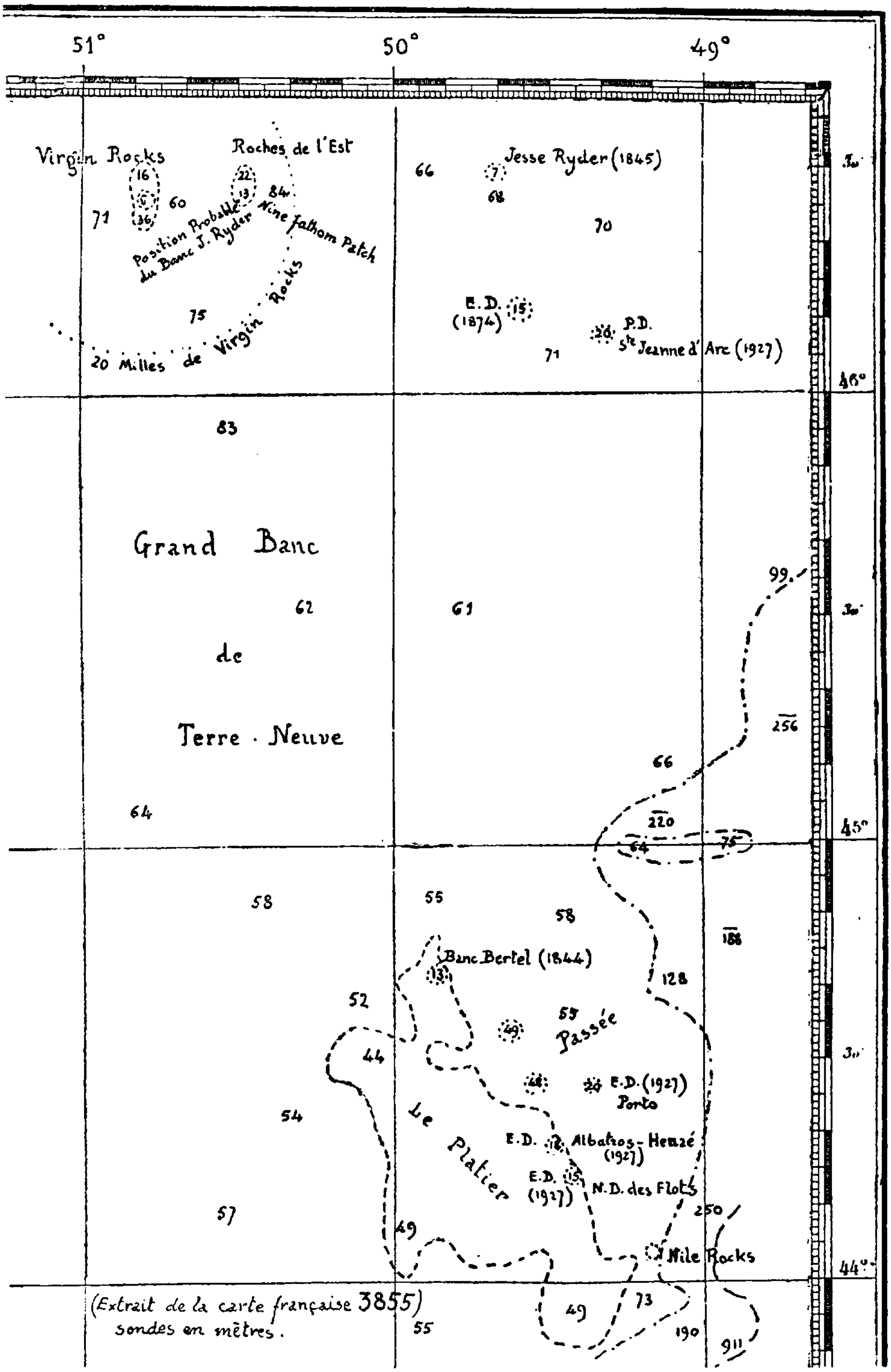
51°
50°
49°
Virgin Rocks
Roches de l'Est
Jesse Ryder (1845)
Position Probable du Banc J. Ryder
Nine fathom Patch
20 Milles de Virgin Rocks
E.D. (1874)
P.D. Ste Jeanne d'Arc (1927)
46°
Grand Banc de Terre · Neuve
45°
Banc Bertel (1844)
Passée
E.D. (1927) Porto
E.D. Albatros - Heuzé (1927)
E.D. (1927) N.D. des Flots
Le Platier
Nile Rocks
44°
(Extrait de la carte française 3855) sondes en mètres.

*Fig. 1*