

## PROGRAMME OF LECTURES

### FOR HYDROGRAPHIC ENGINEERS INSTRUCTION

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The *Service Hydrographique* of the French Navy has communicated to the International Hydrographic Bureau the programme of the various lectures delivered in view of the instruction of Hydrographic Engineers during the year 1942-43.

The data concerning the programme of instruction are given hereafter.

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- A. Lectures on Position Astronomy and Navigation. (1)
  - B. Lectures on Geodesy. (2)
  - C. Lectures on Hydrography and Marine Cartography. (3)
  - D. Lectures on Tides. (2)
  - E. Application of Radio-electricity and Acoustics to Hydrography. (4)
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#### A. — LECTURES ON POSITION ASTRONOMY AND NAVIGATION.

##### I. — THE PRINCIPLES OF POSITION ASTRONOMY.

1. *Formulae of Spherical trigonometry.*  
The fundamental formula of spherical trigonometry.  
The 3 fundamental equations.  
Solution of triangles.  
Borda's formula — Napier's analogies — Right angled triangles — Differentiation of the fundamental formula — Seeking favorable conditions.
2. *Fundamental Definitions.*  
Horizontal co-ordinates — horary, geographical, equatorial co-ordinates. — Relations between the various co-ordinates.  
Star globe (Navisphere) — Celestial Planisphere.
3. *Definition of Time.*  
Sundry Times — Mean time — sidereal time.  
Conversion of times.
4. *Ephemerides.*  
Connaissance des Temps — Sun Tables — Moon, planets and stars Tables — Sundry tables.  
Apparent position of heavenly bodies — Aberration — Parallax.  
Stars Catalogues — Reduction to day's position.  
Nautical Almanacs — Air Almanacs — Annuaire du Bureau des Longitudes.
5. *The fundamental problems relating to Position Astronomy.*  
Latitude — Time — Longitude — Azimuth.  
Accuracy required, suitable instruments — methods pertaining to each instrument.

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- (1) Lectures delivered by Ingénieur hydrographe en Chef CHAVANIER.
  - (2) Lectures delivered by Ingénieur hydrographe en Chef GOUGENHEIM.
  - (3) Lectures delivered by Ingénieur hydrographe Principal ANTHOINE.
  - (4) Lectures delivered by Ingénieur hydrographe de 1<sup>re</sup> Classe CROUSSON.

6. *Astronomical observations.*

Principle of Observation — “Eye and Ear” method — Recording method — personal equation — its determination.

## II. INSTRUMENTS.

7. *Sextant* — Description — Testing — Adjustment — Zero correction — Observing. Errors of the Sextant — Apparatus for Testing sextants.
8. — Altitude position line — Details of observation — Sights reduction — Calculations — Bertin's Method — Simultaneous altitude position lines — The fix at Noon — Meridional observations — Circummeridional observations — Circumzenithal observations (pro memoria) — Sun observation — observation of 1st and 2nd magnitude crepuscular stars, of the Moon, of the planets.
9. Artificial horizon — Description — installation — trough — mercurial trough — Altitude position line — Meridional observation — Time and Latitude by means of equal altitudes — Circummeridional observations.
10. *Theodolite.* — Description — levelling — testing the axes perpendicularity — collimation — Adjustment — Errors of the theodolite.
11. Azimuth by means of the theodolite — Sun azimuth through zenithal distances. — azimuth by means of the Pole Star — Azimuth through disjunctive circumpolars.
12. Latitude by means of the Theodolite — Latitude by zenith distances — Latitude by equal altitudes — Latitude by circummeridian observations — Latitude by the Pole star.
13. Time determination by means of the theodolite — Time by zenith distances — Time by equal altitudes.
14. Complete fixing position by Talcott's method.
15. *Astrolabe.* — a) Principle and description — Influence of errors on the result of observations — Prism — Telescope — extra thin layer mercury trough.  
 b) Setting-up — Adjustment — Testing — Observing method — preparation of observations.  
 c) Reduction of observations — Calculation for lines of position — synthesis of calculations — graphic method — Cauchy's method — Determination of position.  
 d) Re-determination of stars of erroneous position.
16. *Transit Telescope.* — Description — installation — observations — reversion — level — trunnions inclination — inclination correction — Meyer's formula — Micrometer — No collimation cross-line — Repsold impersonal micrometer — Staff — Azimuth of the staff — Calculation for the time or the right ascension of a star.
17. *Meridian Circle.* — Description — installation — observation — nadir — reversion — microscope calibration — Calculation for the latitude or the right ascension of a star.
18. — *Chronographs.* — Button or push chronographs — overtaking handle chronographs — Registering chronographs — electro magnets — oscillographs — Desnetz signals. — Boullite recorders and polygraphs — Hughes printing chronograph — Morse chronograph.

## III. TIME — TIME MEASUREMENT — TIME KEEPING.

19. *General.* — The first point of Aries — its apparent motion — sidereal and mean time — The international meridian — origin of hour angles (time).  
 The International Time Commission — The Paris Observatory and associated observatories. — Chronometers error and the daily rate — Comparisons — apparatus for taking comparisons.

The principle of isochronism — the pendulum and the spiral — Inventions by Galileo, Le Roy and Philipps.

20. *Time keeping machines — Chronometers.* — Description — Constituent parts — Spring balance — spring detent escapement — clock work — upper and lower pivots — Horizontal calibration, calibration for inclination and temperature — contact chronometers.  
*Watches.* — Description, spring balance — Terminal curves — compensation balance — lever anchor escapement — Rak lever adjustment.
21. *Chronometers Competitive Testing.* — Rules followed in France and in foreign countries — Eliminating rates.
22. *Clocks.* — Pendulum clocks — Balance for temperature — gridiron — mercurial — invar — bamboo — grasshopper — escapement — weights. — Electric winding clocks — Constant pressure clocks — Electrically driven clocks — Quartz stabilised clocks.
23. *Time Keeping Methods.* — Time keeping by means of clocks and chronometers — Use of the rates — Examination by means of comparative rates — Service Hydrographique method. — Determination of the error by astronomical observations — Determination of the Error by Wireless time signals — Automatic and rhythmic time signals. — Time dots for mariners — Distribution of the time in a country, in a town, in a building. — Telephone — Telegraph — Loud spoken time signals — Controlled electro magnetic clocks.

#### IV. THE LONGITUDES.

24. *Difference of Longitudes — the International Greenwich meridian.* — Fundamental Longitudes — Secondary longitudes — Absolute longitude — Difference of Longitude determination — Time transporting by ships, by aircraft, by telegraph, by W/T. — Transmitting and Receiving time signal apparatuses. — Longitude bench.

#### V. NAVIGATION.

25. *Use of Mercator's Chart.* — Meridional parts — orthodrome and loxodrome — Navigation problems.
26. *Dead Reckoning Navigation.* — Dead reckoning — drift — magnetic compass — variation — deviation — annual change — the patent log — walker's log — electric log — pressure log — Heavenly bodies rise and set — amplitude — twilight.
27. *Astronomical Navigation.* — Morning fixing position — Noon's Fix — Marcq St Hilaire position line — Altitude of the Pole Star — Azimuth of the Pole Star — Position Fixing Tables — Traverse Tables — Azimuth Tables.  
*Navigation without horizon* — Gyroscope Sextant — Bubble Sextant.
28. *Coastwise Navigation.* — Fixing position by bearings — Fixing position by subtended angles — station pointers — selection of the position, case of systematic error, case of accidental error.  
*Air Navigation.* — Radiogoniometric bearings — their correction — Lecocq method. — Radiodrome — Littrow's Chart.

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#### PRACTICAL TRAINING.

1. *Manipulations during theoretical lectures.* — Sextant — Artificial horizon — Theodolite — Astrolabe — Meridional Circle — Gyroscopic sextant — Bubble sextant.
2. *Field Training.* — Adjustment and Sextant observation — Artificial horizon (setting-up and observation) — Theodolite: Adjustment and Sun observation — Astrolabe: observation — Transit Circle: observation — Rhythmic signals.

3. *Efficiency Training.* — Sextant Sun observation (morning position line) — Complete fixing position by means of artificial horizon (morning position line — meridional — evening position line) — Azimuth by means of theodolite and Sun — Azimuth and Latitude by means of the theodolite and Pole Star — Complete Astrolabe observation — Transit Circle observation — Complete fixing position by means of the gyroscope sextant and bubble sextant.
4. *Calculations.* — Calculation of the Sextant morning position line — Calculation of the fix by artificial horizon observations — Calculation of the azimuth by Sun observation — Calculation of azimuth and latitude by the Pole Star — Preparation of a tabulation and a list of settings for the astrolabe — Calculations resulting from astrolabe observations — Preparation of Transit Circle observations — Calculations resulting from Transit Circle observations — Air navigation calculations.

## B. — LECTURES ON GEODESY.

### I. PRELIMINARIES : *General information on applied geodesy.*

#### 1st Part — MEASURING INSTRUMENTS.

- a) *Constituent parts of measuring instruments* — Level — telescope — limbs — verniers — microscopes — micrometers — limb illumination — telescope illumination — diagonal eye piece — prismatic eye pieces — reticules — cross wires, fitting in new wires.
- b) *Angle measuring instruments.* — Azimuth Circle — Microscope Theodolites — Verniers Theodolites — Wild Theodolite.
- c) *Base measuring Apparatuses* — Jæderin Wire — Brunner's Rulers — Tapes.
- d) *Levels* — Barthelemy — Wild — Bourdaloue staves — Swedish staves.
- e) *Topographic Instruments* — Goniometry — Stadimetry — Altimetry.

#### 2nd Part. — FIELD WORK.

Reconnaissance and Marking — Land, Solar and optical signal marks — Base measurement — Angle measurement (angle method, horizon rounds method) — Execution and plotting of the stations — Center reduction — phase of signals — Supplementary Triangulation — Summary triangulation — Geodetic levelling — Geometrical levelling.

#### 3rd Part. — GEODETIC CALCULATIONS.

- a) *General* — Reduction of triangulation data — Terrestrial ellipsoid (formulae — numerical values — tables) — Calculation of the arc of meridian — Change of ellipsoid.
- b) *Calculation in geographical coordinates* — Legendre Theorem — Calculation of triangles — Calculation of the geographical coordinates — Formulae of the geographic engineers — Calculation of  $L_1$  and  $G_1$  in terms of:  $L_0$ ,  $G_0$ , azimuth and distance. — Calculation of azimuth and distance in terms of:  $L_0$ ,  $G_0$  and  $L_1$ ,  $G_1$  — Mossard Tables — Heights calculation. Reduction of bases to sea level.
- c) *Least square theory* — Analytical theory — Compensation in the case of a triangle, of a quadrilateral.
- d) *Use of rectangular coordinates* — Rectangular coordinates — Problem of the traverse of the station triangle — Calculation of measured distances (bases de vitesse) — Change of system of coordinates (Triangulation — rotation — expansion).
- e) *Assumed position method (Méthode du point approché).* — Use of geometrical position loci — sensitiveness and accuracy of geometrical position loci — Problem of fix by resection — Problem of fix by station — Problem of fix by mixed data — Direct method — Back bearings — Reverse cuts method — Application of the assumed position method in calculations by means of rectangular coordinates and in calculation by means of geodetic coordinates —

- Influence of errors — Error on sighted points — Errors on known points — Influence of intersection of geometrical position loci — Graphic compensation — Selection of the position.
- f) *Use of an extended plane representation.* — Deformation — selection of a definite plane representation — Conformal representations — Various systems of representation: usual geodetic rectangular co-ordinates, azimuthal, Lambert, stereographic, Gauss conformal coordinates — Relations between geographical co-ordinates — Serial development formulae — Projection Tables — Calculation of Projection Tables — use and interpolation of Projection Tables — change of projection system.
- 4th Part — CHART PROJECTIONS — Mercator's projection — Loxodrome — Orthodrome — Meridional parts and Givry's correction on the sphere and the ellipsoid — Bourgonnier's projection — Littrow projection — Radiodrome — Principal projection used in cartography (according to Germain).
- 5th Part — DYNAMIC GEODESY — Gravity measurement — Kater's pendulum — Desforges pendulum — Father Lejeay pendulum — Gravity measurement at sea — Wening Meinesz apparatus — Plumbliné deviation — the Geoid.
- 6th Part — SUPPLEMENT — 1°) Theory of observation errors — 2°) Azimuth determination in view of observing a star near the horizon by means of the azimuth circle. — Favourable conditions — Selection of the Star.

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#### PRACTICAL TRAINING.

- 1st Part — *Use of Instruments* — Azimuth Circle: preliminary adjustment — determination of the constants — calibration. — Execution of a station. — Microscope theodolite: preliminary adjustment — calibration. — Execution of a geodetic levelling. — 10" Theodolite: Execution of a station, measurement of zenith angles. Wild G.M. theodolite: Execution of a station. Wild P.M. theodolite: Execution of a station — Execution of a geometrical levelling — Base measurement apparatus, demonstration of use — Wild level: Execution of a levelling — Kern tacheometer: Execution of a traverse.
- 2nd Part — *Calculations* — Reduction of the principal stations carried out — Calculation of a geodetic triangle in terms of geographical co-ordinates — Heights calculation — Calculation of a 5 kilometres traverse with closure. — Calculation of a measured distance (base de vitesse) — Change of origin in plane coordinates — Calculation by means of geometric loci and calculation of position by bearings. — Calculation by geometric loci, calculation of a position by the station (by the distance to the assumed approximate position and by reciprocal bearings cuts) — Calculation by geometric loci: calculation of a mixed position — Transformation of geographical co-ordinates into rectangular co-ordinates and reciprocal transformation (usual coordinates, coasts of France). — Same problem (azimuthal co-ordinates, Indo-China). — Same problem (Lambert coordinates, Algeria). — Laying out of meridians and parallels on a plotting sheet — Transformation of a S.H. position into an S.G. Lambert position and reciprocal transformation (coasts of France). — Calculation of a Mercator's net.

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### C. — LECTURES ON HYDROGRAPHY.

#### 1-2. — SURVEYS IN GENERAL.

*The Surveys:* Work common to all surveys — Work special to Hydrography: Geographic position of the origin — base — orientation — Large scale surveys — small scale surveys — Precision surveys — Deep sea surveys — Bathymetric soundings.

*Starting point of a Survey:* Origin — base — azimuth.

*The triangulation* : Necessity of a triangulation appropriate to the dimension of the survey — The preparation of the field — Marking of the field — The Marks: description and mounting — Multiplication of fixed positions by theodolite stations — Floating beacons — lines and systems of floating signals — description and anchoring — Floating beacon triangulation — taught wire distance measurement.

*The Controls* : The system of rectangular co-ordinates — The notion of cuts (gisements) — the network of projection plotting sheets and the plotting of stations on the sheets — Scales of Surveys and limits of adjacent sheets. — The various kinds of projections and plotting sheets.

*Surveys without triangulation* : Running surveys — The hydrographic engineer's problem — Roadstead survey by azimuth and distance — mast-head altitude — range finder — Stations at sea — magnetic and astronomical bearings — angles by circle (sextant) — Photographic traverse — Natural controls on photographs — Geodetic polygonals — Control astronomic positions — Exploring survey in secondary rivers.

### 3 — TIDES IN GENERAL :

The setting up of tide-poles : hydrographic levelling, control, observations. — Tracing of curves — Determination of the zero of soundings — use of Favé maregraph for establishing the data of concordance — Areas of similar corrections — Provisional tide curves for sounding correction — Tide tables (yearly).

### 4 — SOUNDINGS - FIXING THE POSITION :

Fix at sea by means of magnetic bearings — by astronomical bearings — by subtended angles — by objects in range — Standard compass for bearings determination — Borda's reflecting circle — hydrographic circles — 180° circles (description — dismounting — remounting — adjustment — calibration) — Formula for horizontal angle reduction — Dead reckoning sounding — Soundings by astronomical position — Combination of the various data and determination of the most probable track — Sound ranging — Selection of points for fixing station position: sensitiveness — Resection angle.

### 5-6 — SOUNDINGS - DEPTH DETERMINATION :

*Sounding lines* : hemp lines — flag line — metal wires — piano wires — marking of lines — registering sheaves — line correction — expansion of lines — inclination of the lead line — curvature of the lead line into water.

*Plumb weights* : Olive lead — Fish lead (plomb poisson) — Marti depth recorder descent of lead into water — use of lombs — Sounding rod.

*Sounding devices* : hand-lead — sounding chains or chair — trolley sounding (Favé system) — Counterpoise sounding (Sommerville system).

*Winches* : Sounding winch — Electric winch — Sounding machine.

*Sounders* : Thomson sounding machine — Warluzel sounding machine — Lucas sounder — Sonic and ultra-sonic sounding machines — Pneumatic sounders — Piezometric sounders.

### 7 — CARRYING OUT OF SOUNDINGS :

*Preparation* : System of sounding lines — ranges — subtending angle arcs and other systematic arrangements — Preparatory projection sheet — boat projection sheet.

*Sounding system* : rowing boat sounding — steam launch sounding — motor boat sounding — main ship soundings — echoscope sounding — deep sea soundings — Formation of sounding parties — function of the personnel — nature of bottom — Sounding record book — record book keeping.

### 8 — PLOTTING SOUNDINGS :

*Station plotting* : Plotting sheets — Vernier protractor plotting — divided perpendiculars — auxiliary lines — auxiliary circles — diagrams — doubling plotting — additional parts — station pointer.

*Lettering of soundings*: Lettering plotting sheet — Station transfer tracing — reduction of soundings — U.S. diagrams — Echoscope soundings — Transfer of sounding stations — distribution between stations — Sounding sheets — Sounding lettering — positive and minus (negative) soundings — outlining of depth curves from meter to meter — Selection of soundings tracing.

*Sounding Control*: Control cross lines, statement of divergencies, — errors research.

9 — SPECIAL SEARCH FOR ROCKS AND SHOALS:

*Search by inspection*: Indicative signs of existence of rocks — favourable circumstances for the search — ripples indication.

*Systematic Search*: Selection of soundings to be searched for, resection net and sounding multiplication — Preparation for the search — Carrying out the search — Plotting of the search — Rock marking — Rock marking sheet.

10 — SWEEPING.

*Towed sweep* at constant immersion — principle of the prism — submarine sentry Description of gear — working.

11-12 — HYDROGRAPHIC SWEEP.

American sweep, light Brunel sweep — rigid finnish sweep — Preparation of sweep strips — Carrying out the sweeping, book keeping — Depth control — plotting.

13-14 — TOPOGRAPHY.

*Fixing position*: methods, stations — Intersection — radial sights — traverse — resection. — Theodolite — description — dismounting and remounting pieces — Divided poles (mires parlantes) — stadias — measuring chains — plane table and declinator — Levelling alidade — Eclimeter ruler — holometric alidade — Method of inverted cock hats.

*The system of topography*: Theodolite topography — parties — record book — functions of the personnel. — Circle topography — parties — record book — functions of the personnel. — Boat topography — parties — record book — functions of the personnel — boat anchoring — special staves. — Rock topography, parties — execution — Rock elevations — plotting — drafting.

*Sketches and Photographs*: Conventional symbols — sketch standardising — indication of stations and staves positions — Scale of the sketch — Use of air photographs — indications to be marked on the field.

*The plotting of topography*: Construction plotting sheet — Drafting plotting sheet — station plotting — staves plotting — use of air photographs — Restitution — anharmonic pencil of rays — height correction — topographical drafting — conventional symbols and colours.

15 — PLOTTING SHEETS.

The drawing up of meridians and parallels on sheets — Calculation of geographical positions — Meridian convergence.

16 — AIR PHOTOGRAPHS.

Air cameras — conditions for taking air photographs — over lapping — altitude — scale — inclination. — Restitution apparatus — camera lucida — Vavon — Roussilhe air photograph plotter — stereophotogrammetry — Poivilliers stereo-autograph — stereocomparator — stereoscopic effect — “baloon” collimating mark — General information concerning various French and foreign photo restitution apparatuses and the development of photogrammetry from Laussedat up to date — Panoramic apparatuses — Long focal distance apparatuses — Teleobjectives — Phototacheometer.

17 — OCEANOGRAPHICAL OBSERVATIONS.

*Currents*: Observation. — Float apparatuses — propeller apparatuses. — Ohro-dag-Muldedag-Idrac-Wollaston-Eckmann — Selection — plotting — various diagrams in use — decomposition of the vector according to two rectangular axes for smoothing curves.

*Sea water samples* : Temperature — salinity — solved gas (oxygen and H<sub>2</sub>S) — Richard bottle — Thoulet densimeter — Richter Hermometer — Sampling devices — hydrometric stations.

*Bottom samplers* : Buchanan — Leger — Schlumberger core sampler. — Rondeleux collector — Charcot dredge.

18 — MAGNETIC OBSERVATIONS.

Variation — Dip — horizontal component of the magnetic force — Instruments — observations. — Diurnal change; annual, secular change. — Declinators (Variation compasses) and Variation observation spots.

19 — ORGANISATION OF HYDROGRAPHIC EXPEDITIONS.

Personnel — Engineers — surveyors material of Hydrographic Service, of the Navy Supplying Service — Report on Expedition.

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C'. — MARINE CARTOGRAPHY.

1. — DRAFTING OPERATIONS. — Selection of soundings in view of reduction — Tracings with large scale numbers — Photographic reduction — Pantograph — Calculation of the projection — meridional parts — drafting of the net — Borders and Title — Constitution du polichinelle — Pink tracing — heliogravure tracing — Use of the pantograver — Use of various compilation documents. — Preparation of "Edition", of "Remplacement", of an inset (annexe graphique).

2. — REMARKS CONCERNING CHARTS AND PLANS [Ouvrage N° 13-9 (ex. 971)]. — Lettering-Numbers and Conventional Symbols — Sea marks — lights — buoys etc. — Titles and sub-titles — Variation, etc. — the reading of foreign charts — Comparative I.H.B. symbols — Classification of lights and fog signals — Light legends — Light legend simplification — Legends to be put on charts.

3. — ENGRAVING AND CHART PRINTING. — Line (burin) engraving — line block printing, lettering, tint stippling — S.H. lettering pattern type — talonnade — échappage & liaisons — stippling machine — Engraving and framing machine — Chart paper — quality and size — Typography, types, composition, justification — printing machines — Lithography — principle — preparation — transfers — lithographic printing machines — plates — roto metal — roto-calco.

4. — THE VARIOUS REPRODUCTION METHODS. —

*Photo-mechanical processes* : Glue and albumin process — Copper plate heliogravure — Zinc heliogravure — gelatine process — Dorel process — Water or Amoniac vapour developping papers — Mercurial vapour electrocopying.

*Photography* : Line and half tone blocks — gratings — resin powder heliogravure — Colour photography — Screens — studio camera — prism objectives — Collodion and gelatino bromide — Giflex process — Vitrification — Illumination of the object.

5. — CHART CORRECTION. — Notices to Mariners — Notices relating to books, notices relating to charts — Insets — Publications — Editions — Remplacements — Ouvrage N° 5 — To verify if a French Chart is corrected up to date.

6. — NAUTICAL BOOKS. — Sources — Preparation, compiling, correction, Revision of books — Sailing directions — Light Lists — Ouvrages 2, 2A, 2B — List of signal letters of ships — BUTT and P.T.T. publications — International Codes of Signals — Album of Flags and Pennants — Distance Tables.

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C''. — PRACTICAL TRAINING.

1. — *Field training* : Marking the lead line (1 exercise) — Adjustment and use of the hydrographic circle and 180° circle (2 exercices) — Sounding (12 exercices) — Topography (5 exercices) — Measurement of magnetic data (1 exercise).



2 — *Efficacy operations*: Sounding: hand lead sounding in rowing boat (5 exercises) — Fish lead sounding in motor boat (15 exercises) — Topographic survey without air photograph (3 exercises) — Topographic survey together with air photograph (3 exercises) — Measurement of variation (3 exercises).

3 — *Calculations - Drafting - Plotting*:

- Soundings* — a) Drafting the grid network on the plotting sheet. — Station plotting — Additional (3 exercises).  
 b) Laying off the proposed sounding lines. Angles measurement. Boat sheet (2 exercises).  
 c) Calculation of a divided perpendicular, of an auxiliary line, of an auxiliary circle (5 exercises).  
 d) Use of diagrams for dividing perpendiculars. Sheet graphs (1 exercise).  
 e) Plotting of soundings (10 exercises).  
 f) Insertion of tidal data on sounding book — Reduction of soundings (1 exercise).  
 g) Lettering sounding numerals — depth curves. Preparation of a search for shoal (6 exercises).

*Topography* — Plotting and drafting a topographic survey (5 exercises).

*Currents* — Plotting of current measurements (2 exercises).

*Cartography* — Selection of soundings according to various scale reductions (5 exercises). — Enlarging the stations (1 exercise) — Reduction by the small square method (1 exercise). — Calculation of a graphic scale (Charts) (1 exercise) — Correcting a chart by means of the Notices to Mariners (1 exercise) — Plotting of meridians and parallels on a plotting sheet (4 exercises) — Common calculation for Latitude and Longitude (1 exercise) — Calculation of a grid (2 exercises).

## D. — LECTURES ON TIDES.

1st Part — TECHNICAL NOTIONS.

1-2-3-4 General and Definitions — Generating force of the Tide — Small motions law (Painlevé) — Development of the Newtonian potential. — Study of the Tide in the case of an Equatorial canal (Hatt).

2nd Part — TIDAL OBSERVATIONS.

5-6-7-8 Tide poles — Chazallon tide gauge — Favé tide gauge — Gironde tide gauge —  
 9-10-11 Harmonic Analysis — scrutinizing of observations — Tide separation — harmonic constants — over and compound Tides — stationary waves — Study of tide in a port — typical curve — concordance tables — Laplace formula — Tide in Lower Cochinchina (Héraud & Arago).

3rd Part — TIDAL PREDICTION.

12-13-14 General — Calculation of the elevation of tide at any instant in terms of the  
 15-16 harmonic constants — Tide predictor, description, working. — Prediction of Tide at Brest — Various prediction methods — Bencker's method — Summary prediction — Tide tables. — Mean level determination — medimarmeter — Accidental changes of the sea level — seiches. — Influence of pressure on sea level — Lowest low water level — Highest high water level — Chart datum — information to be put on charts.

4th Part — RIVER TIDES.

Tidal streams — selection of observations — synthesis and prediction.

## PRACTICAL TRAINING.

- 1°) All practice work as shown in Mr. M.A. COURTIER Treatise on Tide, Paris, 1937.
- 2°) *Tides poles* : Setting up, determination of inclination, connection to a neighbouring tidal datum, to a N.G.F. bench mark.
- 3°) *Favé Tide gauge* : Preparation, mooring, heaving up, analysis of records.
- 4°) *Missiessy Tide gauge* : Adjustment.
- 5°) *Tide Tables* : practice of the "Annuaire des Côtes de France" and Tables for the French colonies.

## E. — APPLICATION OF RADIO-ELECTRICITY AND ACOUSTICS TO HYDROGRAPHY.

### INTRODUCTION.

1. — The various applications of submarine acoustics, namely sounding and sound ranging. — Peculiarities of sound propagation in liquid medium.

### ELECTRICITY

- 2-3. — General — Recollection of the fundamental principles of Electricity — Electromotive force — Intensity — Resistance — Self and capacity — Ohm Law — Kirchhoff Law — Joule Law — Electrostatic unities — Electromagnetic unities — fundamental measuring apparatuses — Voltmeter — Ammeter — Ohmmeter — Wavemeter — Resistance measurement — Tension measurement — Intensity measurement — Self induction measurement — Capacity measurement — Insulation measurement — Conductivity measurement.

### RADIO ELECTRICITY.

4. — Electrical Oscillations, wave length — Wave length measurement formula.
5. — Influence of waves on circuits — permanent system.
6. — Influence of waves on circuits — transient system.
7. — Valves — Principle and study of the diode.
8. — Valve lamp and rectifiers — Tungar — Cuproxide.
9. — The triode — static and dynamic characteristics — Amplification — A.B.C. Regimen.
10. — *Oscillation function* — Heterodyne — Valves fitted with more than 3 electrodes (tetrods, pentods).
11. — Spark, arc, alternator, valve senders — Destroyer transmitting set, navy type.
12. — Tension and power amplifiers.
13. — Detection — Various types of detectors — Navy receiving sets — Antennae — Loops — Direction finders (Radiogoniometers).
14. — Amplifiers used by the Service Hydrographique for sounding and sounding ranging purposes — Description — schema of principle — Tyatron.

### ACOUSTICS.

15. — Microphones — Solid Bac — electromagnetic and electrodynamic microphones. — General theory of Sound propagation — Velocity of sound in the air, in the water. — Influence of density and compression of medium.
16. — Reflexion and Refraction — mirage — interferences — Directional transmitters and receivers — Doppler effect — Diffraction effects — limitation of the transmitting beam — Ultra sonic directional transmission.

17. — Piezo electricity and Magnetostriction — S.C.A.M. quartz and Husun B.B.T. oscillator — Resonance phenomena — tuned plates diaphragms.

## SOUNDING.

18. — Sonic Sounding — Sonic and ultra sonic apparatuses — sounding corrections — change of velocity of sound according to depth — Side echoes — Reflexion on bottom — Double transmitting echoes and sonic and ultra sonic receivers.
19. — Transparent plates — quart d'onde — ballast receivers — Valves-Periscopic arrangements — streamlined casing receivers — Influence of ship stream lines — air bubbles.
20. — Chronometer-motors — synchronized motors — tune fork control — friction control motors — clockwork springs motors — centrifugal control.
21. — Amplification and measurement of time interval — Recorders and reading devices — lamp black — electrolytic registering.
22. — Ultra sonic apparatuses (Marty U.S. — Echoscope — Touly).
23. — Magnetostriction apparatuses (Husun B.B.T.).
25. — Fessenden apparatuses (american system).
25. — Sonic apparatuses — Detonation successive shocks sounder — Continuous C.E.T. hammer sounder.

## SOUND RANGING.

26. — Sound Ranging — method — gear — corrections — station plotting — sonic mirage — Explosions — microphones — amplifiers — Boullitte recorder — portable W/T set — american appliances.

## MAINTENANCE AND EXAMINATION OF GEAR.

27. — The laying out of submarine microphones — case container anchoring — wiring cables — leading cables checking.
28. — Checking appliances — outbreak refitting, inspection and maintenance of gear — Use of E.E. Voltmeter — Use of rectox U.S. control — Use of cathode oscillograph.
29. — Examination of the quality of quartz — the crevasse.
30. — Quartz pasting.

## PRACTICAL TRAINING.

1. — Various electrical measurements.
2. — Determination of the characteristics of a diode valve, etc.
3. — The Echoscope (5 exercises in roadstead).
4. — The ultra sonic sounder (1 exercise).
5. — The hammer sonic sounder (1 exercise).
6. — Polygraph recording of a W/T signal followed by an explosion transmitted through water.

