St. John's, Robert CHAPUIS lecture. July 2001

Transatlantic telecom relations: some short stories about them

1. Introduction

I shall address you on the history of what we can call "the transcontinental telecom relations." The ones that began of course through the Atlantic Ocean but that were followed immediately by several other transoceanic relations.

It is a long history spanned over more than 150 years. It is a history that had been covered by many books and, even more, by plenty of historical articles in telecom reviews. However, time passing, all these documents are generally ignored or have disappeared from collections of old archives.

In front of you, what I can offer you will only be some souvenirs of the old time successes of these transcontinental relations. To do that, I shall use displayed reproductions of some fine engravings appeared in books of the 1870-1900 period. For more modern times I shall also refer to some personal souvenirs of the forty years (1944-1984) of my international career.

I shall also, here, in Newfoundland, limit myself on what concerns the most important part, but nonetheless limited, of these intercontinental relations: the transatlantic relations, and especially those by submarine cables.

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According to what is a favourite concept of historians, "the periodisation," the development of transoceanic submarine cables can be divided in three different periods:

- the era of telegraphic cables, 1866-1960, the era that we can call the one of "grand-grand fathers" (or more ancestors) of the present generations;
- the era of the (analogic) telephone cables, 1956-1999, the one of the "fathers;"
- the era of the present optical fiber cables, with digital transmission, which is now an activity on the forefront of financial enterprises and the subject of so many technical symposiums.

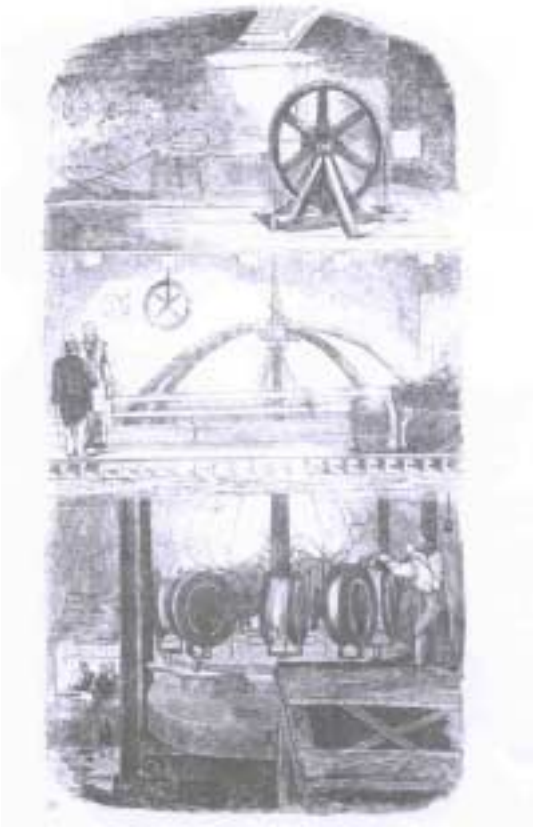
Obviously only the two first of these three periods are subjects for meetings of historians of telecoms and will covered here. The third one will be a very interesting matter - economic considerations, concurrency with other transmission mediums, etc. - for such meetings but not before 10 or 20 years!..

2. The first Telegraphic connections across the Atlantic Ocean

(ref. 1 and 8)

2.1 It is in 1852 that the idea of connecting America and Europe by a submarine cable took place. A British engineer, Mr. GISBORNE, is at the origin of the idea. He had been inspired by the success of the submarine cable across the Channel between England and France (a short distance - 30 km - between Calais and Dover): a first cable laid in 1850, but of a very

short life since cut by fishers, and in 1851 its replacement by another one which offered the success of the relation.



The project of a transatlantic cable was of course a matter of a completely different magnitude. GISBORNE succeeded to have a rich American banker, Mr. CYRUS FIELD (1819-1897), sharing his convictions and in 1854 the "Atlantic Telegraphic Company" was funded.

A cable was designed and built. Its cable core was of seven copper wires, put inside three layers of gutta-percha. The total core had a diameter of 12.2 mm. The core was wrapped inside a sheath of eighteen strands, each composed of seven steel wires.

The cable was intended to join Valentia in Ireland and the Newfoundland: a distance of 3800 km.

On July 27 of the year 1857, two ships specially fitted for telegraphy and with all the apparatus for laying down a cable:

the H.M.S. AGAMEMNON, sailing from Valentia (Ireland), and

the US ship NIAGARA, sailing from St-Johns (Newfoundland) met at mid-point across the Atlantic

On August 5, the electric connection (return current by the sea water) was set up between the two sections of cables brought by the two ships and on August 18, CYRUS FIELD was able to send his first telegraphic message:

> *"Europe and America are united by telegraphic communication. Glory to God in the highest, on earth peace and goodwill towards the men."*

Cyrus Field had a triumph in New York. Great Britain intended to do similar festivities when!! … When, unfortunately, on September 3, 1858, the connection was broken, and that for still many years to come.

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The US Secession War (1861-1865) suspended during some years the efforts of Cyrus Field but his energy took over. He obtained new capital funding for his Company which took a new name, the "*Anglo-American Telegraph Co.*" A new cable had to be built: a cable three times heavier than the precedent. The cable-ship to be freighted was the biggest steel steamship of his time: she has to store in her holds the terrific weight of a length of 3700 km of the cable. She was the "GREAT EASTERN" ship, a name famous in the telecom history.

The first attempt to lay down the cable was in July 1865. Attending to this trial and on board the Great Eastern were Professor William Thomson (later Lord Kelvin), the highest scientific authority of England, and several other electrician authorities.

Once again, the 1865 lay-down attempt of the cable was unsuccessful; after 10 days of sea route and half of the cable laid down, it was cut by an accident. After many days in unfruitful trials to recover it, the Great Eastern campaign had to be postponed to the 1866 summer.

1866 is the Victory year: the cable was laid down, continuously, between Victoria (Ireland) and Trinity Bay (Newfoundland). The Great Eastern had another success in the same year: he recovered the section of the cable lost the preceding year and the Atlantic Telegraphic Co. was thus able to obtain two twin cables operating this year 1866 across the Atlantic.

Picking up the transatlantic cable lost in 1865.

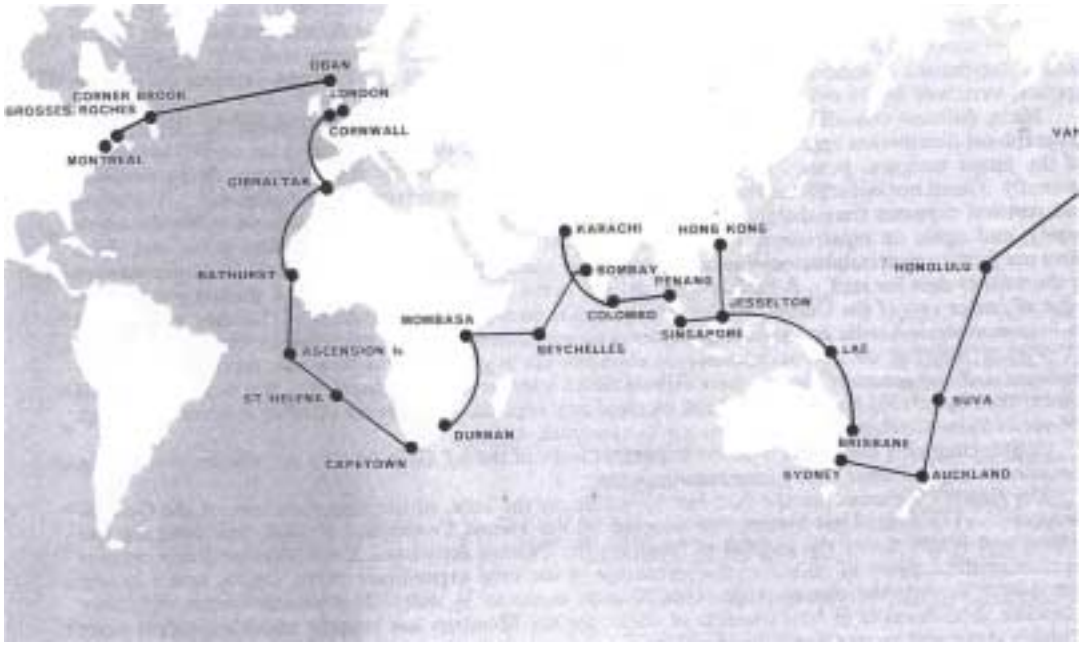
2.2 (ref. 6 and 7) In 1869, a French telegraphic cable, the third transatlantic one, was laid down between France (Brest) and USA (Cape Cod, Massachusetts). It was again the Great Eastern ship which laid the cable. Its manufacture, as for the two preceding ones, was by the British "Telegraph Construction and Maintenance Co" (Tel Con & Maint). Its financing and operation were however the matter of a French company, the "Société du cable transatlantique français." In France it was the time of the very active capitalistic period which marked the end of the French IInd Empire, a time when flows of money went to big projects opening the world to modernity: the long railway lines, the opening (1969) of the Suez Canal, etc...

The disastrous defeat of France in its 1870-71 war with Germany and the heavy financial losses it caused to its economy led in 1873 to the take-over of this French telegraph operator by the Anglo American Telegraph Co.

The latter will nearly reign over the transatlantic activities during many years until the year 1900. Even after a new competitor, the "*Commercial Cable Co.*" had emerged in 1883 in USA. Even also after a new French company (the one very often named PQ according the initials of its founder, Pouyer-Quertier) had opened in 1879 a cable between Brest and St Pierre et Miquelon (the French small islands, near the south coasts of Newfoundland) with extensions to Cape Cod and to Newfoundland.

All these competitions were subjects of several disputes to obtain governmental concessions, disputes generally followed by pool-agreements on traffic sharing and on fixing for the consumer a common uniform price of the "word." A price which, from 1866 to 1910, was drastically divided by twenty: from one sterling pound to one shilling.

2.3 The 1870-1910 period was a very active one for the laying of telegraph cables across the Atlantic, as it was (even on a less degree) for submarine cables across many other seas of the world (Mediterranean, Caribbean seas). It was also the period of a great activity of laying cables for the British Empire to join India and far east countries to Europe through Mediterranean, Aden gulf and Oman Sea.



A Table (origin: Rene Salvador), reproduced in Annex 1, gives the list of the 20 telegraph cables laid through the Atlantic before the Ist WW, and includes also five others laid from 1923 to 1928.

3. Tentative attempts in 1926-1931 by ITT (Sosthene BEHN)
for the design of a transatlantic telephone cable
(ref. 4 and 5)

At the end of 1925, Sosthene BEHN, president of his brand-new International Telephone and Telegraph Corporation (ITT), had purchased at a huge price from the Western Electric the entire capital stock of its subsidiary International Western Electric (IWEC). The latter was renamed International Standard Electric Corporation. ITT thereby acquired all the companies formerly operated by IWEC in six European countries.

The British company was renamed Standard Telephones and Cables (STC); the Belgian kept its name Bell Telephone Manufacturing Co., as did the French Le Matériel Téléphonique (LMT).

In 1926, "Colonel BEHN", as he was often named,[1] called to his Paris office Maurice DELORAINE, a young French engineer who had been from 1922 in the Western Electric laboratories in London, working on the first attempts of radio telephony across the Atlantic. (In 1927, the first radiotelephone circuit, operated jointly by ATT and the UK Post Office, had been opened to the public service, after a long experimental period: see Box A).

BOX A

20 years after the first detection of a transatlantic radio signal
at Signal Hill -Newfoundland,
In the 1920s, first steps for transatlantic telephone service
via radio connections

Following important progresses during the 1915s on high- power tubes for radio-transmitters, and use of the Single Side Band suppressed-carrier technique narrowing the frequency-band to transmit:

- in 1921-22: first experiments for transatlantic radiotelephone transmission by Western Electric (ATT) with a US transmitter at Rocky Point (Long Island) operating on long-waves.
- in 1923, on January 14/15: first demonstration of telephone calls (one way of conversation) from New York (Mr. Thayer, the President of ATT, and others) to a British audience (Frank Gill and GPO representatives) in London.

- Decision taken by the UK GPO to develop with ATT (International Western Electric) the opening of radio-telephone circuits between USA and UK, followed by a long period of experiments and researches. Installation in England of the radio station of Rugby to communicate with the American one of Rocky Point.

The transmitters at these stations were fitted with batteries of high-power tubes and delivered 200 kW of very-long HF waves to antennas issued from high metallic towers. Reception was through very long horizontal lines across the surrounding station fields.

- in 1927, on January 7: opening to commercial service of telephone relations between London and New York, (with only one circuit), a circuit which is to be considered as offering the first transcontinental telephone relation.

It was soon a commercial success, even if the price of a telephone call was expensive (15 sterling pounds for a 3-minute call), and more than one circuit was needed. Short-wave radio circuits using reflection on the ionospheric layers provided the solution and three radiotelephone circuits of this type supplemented the initial long-wave circuit for ATT-UK (GPO) operation, even if their operation was significantly less reliable.

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[1] Sosthenes BEHN was an American officer, with rank of Colonel, of the US Signal Corps, serving in 1917-1919 in France as Chief of Staff in the Chief Signal HQ.

It was at this time that the ATT joined the CCIF, (the international Consultative Committee for Telephony) and took later a very important role in this Committee, later absorbed by the ITU (International Telecommunication Union).

S. Behn told abruptly to Deforaine that he was greatly interested in his association with the first transatlantic radiotelephone connection, but "while this was a good progress, the real solution would be a submarine telephone cable."

Behn had some experience with the matter of submarine telephone cables. In his Cuban Telephone Cy, he had installed in 1921 a deep-sea telephone cable between Cuba and Key West (the extreme south-end of Florida): a continuously-loaded cable built by a British company. The first cable has met such a success that three others had to be laid in few years. But the distance between the land ends of these cables was a relatively short one and a cable crossing the Atlantic was a problem with a completely different order of magnitude.

Behn expanded the merits of his transatlantic project by pointing out that the cable could handle telephone calls during the traffic hours common to Europe and America and still handle telegrams during the rest of the 24 hours. Continuing to explain that this would give ITT a worldwide reputation, he suddenly asked those present: "Do you know what this young man is thinking? I can tell you, he thinks, I am quite mad!.."

This gave Deloraine a shock... At this time, the understanding of transatlantic telephony indicated that radio was far ahead of cables. The existing transatlantic cables, able to transmit only frequencies less than 30 Hz, were good for telegraphy, whereas a band of 300 to 3000 Hz was required for telephony.

Behn finally set up in London a small group of engineers for the transatlantic cable, under the direction of Frank GILL and George NASH (an ex-Western Electric supervisor). A laboratory was created for the project at Hendon airfield. Researches in various fields took place:

- testing of various types of submarine cables, at pressures corresponding to ocean depths;
- transmission theoretical studies and methods to increase the bandwidth offered by telegraph cables;
- etc...

The idea of developing deep-sea submarine repeaters was at this time rejected as beyond the reach of existing technology.

The system design was to handle only a single-voice one-way channel, with a cut-off frequency at 2400 Hz. The cable will offer a single conductor with current-return by the sea. The conductor was a bunch of several wires of a diameter between 3 and 5 mm, continuously loaded by magnetic tapes applied spirally.

To minimise the distance between the last ends of land and their associated repeaters at the ends of the cable, an ultimate northern route through Greenland and Labrador had been chosen. On a specific cable design, an expected attenuation of 0.15 dB at 2400 Hz per nautical mile was achieved. On this basis, the longest hop, the one between these two land terminals,

would have involved a loss of 85 dB at 2400 Hz. This was enough to frighten any transmission engineer! At this time, the maximum gain offered by a repeater was of the order of 30-35 dB.

Theoretical studies were devoted to estimate the combination of factors offering minimum attenuation. Various types of magnetic alloys were considered for the spiral loading of the wires of the core. Other studies had to deal with noise reduction. An experimental voice-switching equipment to be installed at the ends of the cable was designed since the cable had to be operated one way at a time.

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Such was the stage of this development when in 1929 the historic collapse of the American stock market took place. And with the ITT finances in deep losses, its London Laboratory for the transatlantic project was closed in the middle of 1932.

End of this story.

4. A telephone submarine cable across the British Channel for the landing in July 1944 of the Allied Forces in Normandy: a predecessor of TAT1, the first transatlantic telephone cable

For their 1944 landing in Normandy, Allied Forces set up a series of radical innovations. Firstly their artificial harbours (Arromanches and other sites). Also, worth of mentioning, the "PLUTO" project: a submarine pipe-line for petrol and gasoline supply of the landed troops, a pipe-line laid down by a specially designed cable-ship. Less known, but no less technically remarkable, was the laying of a submarine telephone cable joining SOUTHAMPTON (UK) and France (near CHERBOURG). This cable, although little known, may be considered as the first of its length (360 km) and kind (with 12-channel carrier system), and hence as a "milestone" in the history of submarine cables for telephony.

Since 1866, submarine cables across the Atlantic and other Oceans were used for telegraphy transmission, but their use for telephony was impracticable as soon as the distance between their terminating ends inland exceeded some 50-60 kms.

Here, let me give some souvenirs of the beginnings of my professional career when I joined the "Long Lines" services of the French PTT on July 1st 1944: It was a very hectic and exciting period. Long distances cables were damaged either by sabotages of the French resistance or from Allied bombings, and these damages included also repeater stations. We received urgent requests from the military and civil authorities for quick restoration. I was thus sent in July 1945 to Cherbourg with a British officer of the Signal Corps to work on the terminal end of this cross-Channel telephone cable and on its extension to French long lines cables. This was in a place called URVILLE near the shore along a long sandy beach. Sixty years later, I must say that I remember more of the beach than of the carrier system equipment installed in a small blockhaus.

Hence, I knew the existence of this cable and what it represented for engineers and the history of telecommunications. Twenty years ago, I tried to obtain some reference information on its system structure. The British reply was a fax of only two lines: there were two cables in parallel, of coaxial type (0.62 inch in diameter - the type used by GPO for their land cables), and two carrier systems, each of 12 telephone channels, installed at their terminal ends.

As it happened, I was talking about this historical anecdote with a colleague of mine in ITU Geneva. In 1944, he was the Major D. J. D. DORMER of the Royal Corps of Signals and he was then in charge of installing the carrier system at the French terminating end of the cable.

So, it is directly from his narration that I can offer you the living souvenirs of D. J. D. DORMER of his French landing and equipment installation.

"I was in charge of the 12-channel terminal equipment. Another terminal equipment, identical and as a stand-by, was in the hands of an officer of the same rank, based in Liverpool.

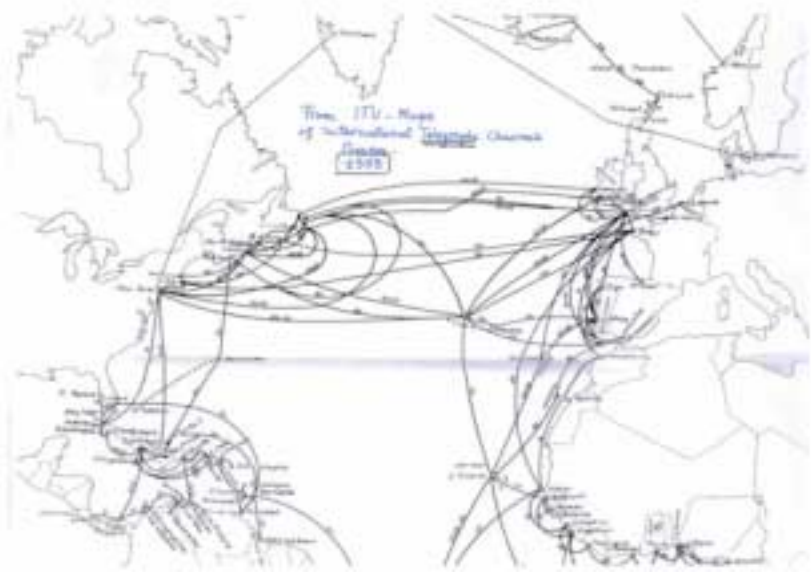
During several weeks, I waited in a camp near Southampton, in utmost secrecy. In July we got on the trucks loaded with our terminal equipment to land at the artificial harbour of Arromanches. And then, not without some difficulties, we arrived to URVILLE. I installed my terminal equipment at the end of the submarine cable. Everything was OK, it was wonderful...

What is rather extraordinary in this setting-up in service, is that the trucks bringing the second terminal equipment from Liverpool arrived at the same time as I did, at a quarter of an hour... But my Liverpool colleague had not been a happy man for his duty. He had embarked on a boat well before the D day (June 6) and he passed six weeks in Ireland sea waiting for his time of landing in France. The Cherbourg peninsula ("the COTENTIN") had first to be in the hands of the Allied Forces and it took time to gain their battle of the North of Normandy."

In the military life, sometimes (but not very often, we have to say), logistics and, more effective, chance have wonderful success! ... "

5. The prodigious development of the intercontinental telephone submarine cables

During the post-WWII years, important progresses were made by both ATT (Bell Labs and Western Electric) and UK GPO for the development of submarine coaxial cables with immerged repeaters.



Two different lines of approach, according the housing of these repeaters existed.

The American one, a Bell Labs design was the one used, with 52 flexible repeaters, in the TAT1 realisation for the transatlantic section and is described in the Lenore Simons lecture of this Conference.

The British one was a follow-up of the technique used for the military cable mentioned under 4 above and it had given rise in 1947-1954 to the laying down of several cables joining United Kingdom with several European countries. It was used for the TAT1 section joining Newfoundland and Nova Scotia.

After the 1956 success of the TAT1 and its American submerged repeaters, 1957 sees with the same technique the laying of the Hawaii 1 cable joining Honolulu to California, and 1959 the laying of a TAT2 joining Newfoundland to France (Penmarc'h, in Brittany), followed during the following years by many other cables joining different continents.

Annex 2 gives the 1990 list of these cables, a list drawn up from ITU collected information (ITU Plan Committee).

BIBLIOGRAPHY

1 Alexis BELLOC. - La Télégraphie Historique, 345 pp.
(cables sous-marins: pp. 217-240)
ed. Firmin-Didot, Paris, 1888

2 E. WÛNSCHENDORF. - Traité de Télégraphie sous-marine, 1888

3 K. R. HEINHE. - Cable Ships and Submarine Cables ed. Allard Coles, London, 1968

4 P. YOUNG. - Power of Speech (A History of STC -1883-1983)
ed. G. Allen and Unwin, London, 1983

5 Maurice DELORAINE. - Des Ondes et des Hommes
ed. Flammarion Paris, 1974
(an English version -same year- also exists)

6 R. SALVADOR. - A short history of French transatlantic telegraph cables, *in* "Instrumentation and Measurements Society Newsletter, 1995"

7 and TABLE of "Les cables télégraphiques transatlantiques posés et exploités de 1858 à 1965" (3 pp.)

8 ITU (a book for celebration of the Centenary of this international organisation). - Du sémaphore au satellite,
ed. ITU 1965 (an English version also exists)

also:
E. E. Blavier: Traité de télégraphie électrique

ed. E. Lacroix, Paris, 1867
J. M. Villefranche: La Télégraphie française
ed. V. Palme, Paris, 1870
L. Montillot: Télégraphie pratique
ed. Dunod, Paris, 1898
J. Ahvenainen: The Far Eastern Telegraphs
ed. Suomalainen Tiedakademia, Helsinki, 1981

ANNEX 1

LIAISONS TELEGRAPHIQUES TRANSATLANTIQUES

Câbles posés et exploités de 1858 à 1965

Note	Pose	Longueur (MN)	Atterrissements	Fournisseur	Navire de Pose	Opérateur	Vitesse (mots/m)	Hors Serv.
1	1858	1910	Valentia - H. Content	Gutta. Percha C° (âme) RS Newall + Glass Elliot	Agamemnon Niagara	Atlantic Telegraph C°	1	1858
2	1865-6	1896	Valentia - H Content	Tel Con & Maint.	G. Eastern	Anglo - American	5	1877
3	1866	1852	Valentia - H. Content	Tel Con & Maint.	G. Eastern	Anglo - American	5	1872
4	1869	2885	Brest - Saint Pierre	Tel Con & Maint.	G. Eastern	Sté du C.Tg. Fr.	10	1893
5	1873	1900*	Valentia - H Content	Tel Con & Maint.	G. Eastern	Anglo - American	15/90	1963
6	1874	1900*	Valentia - H Content	Tel Con & Maint.	G. Eastern	Anglo - American	15/90	1963
7	1875	2423	Ballinskelly - Tor Bay	Siemens Br.	Faraday 1	Direct U.S. Tg Co	20/90	1962
8	1879	2360	Brest - Saint Pierre	Siemens Br.	Faraday 1	C° F. Tg de P. à NY.	20/90	1929
9	1880	1900*	Valentia - H. Content	Tel Con & Maint.	Scottia, Seine	Anglo - American	50/110	1949
10	1881	2518	Porthcurnow - Canso	Siemens Br.	Faraday 1	A.American (WU)	50/90	1963
11	1882	2531	Porthcurnow - Canso	Siemens Br.	Faraday 1	A.American (WU)	50/110	1963
12	1883	2400*	Waterville - Canso	Siemens Br.	Faraday 1	C.C.C.	50/90	1962
13	1884	2281	Waterville - Canso	Siemens Br.	Faraday 1	C.C.C.	50/90	1962
14	1894	2161	Waterville - Canso	Siemens Br.	Faraday 1	C.C.C.	50/90*	1962
15	1894	1900*	Valentia - H. Content	Tel Con & Maint.	Scottia., Britania.2	Anglo - American	50/110	1963
16	1896	3180	Brest - Cap Cod	S. Indust. des Téléphones	François Arago	C.F.C.T.	50/90	1962
17	1900 1900	(1500*) 2300*	Borkum(Porthc)-Horta Horta - New York	Tel Con & Maint. Tel Con & Maint.	Scotia, Caledonia, Britania 2	German A.T. (BPO) German A.T. (BPO)	50/110 90/110	1962 1962
18	1900 1901	1698 1204	Horta - Canso + Waterville - Horta	Siemens Brothers Siemens Brothers	Faraday 1 Faraday 1	C.C.C. C.C.C.	90/110 90/110	1962 1962
19	1903 1904	(1490) 2290	Emden (Brest)-Horta + Horta - New York	Norddeu. Seekabel. Norddeu. Seekabel	Stephan Von Podbierski	German A.T. (PTT) German A.T. (PTT)	50/110 50/110	1962 1962
20	1905	1807	Waterville - Canso	Siemens Brothers	Faraday 1	C.C.C.	90/110	1962
21	1910	-	Penzance-Bay Roberts	Tel Con & Maint.	Colonia., Telconia.	A.American (WU)	90/110	1963
22	1923 1923	1200* 1700*	Waterville - Horta + Horta - Canso	Siemens Brothers Tel Con & Maint.	Faraday 2 Colonia	C.C.C C.C.C.	170 170	1962 1962
23	1924 1924	2300 1337	New York – Horta Rome – Malaga - Horta	Tel Con & Maint Tel Con & Maint	Colonia Colonia	Western Union Italcable	170 170	1966 1966
24	1925	3410	Bay Roberts-Sennen Cove	Tel Con & Maint.	Colonia	Western Union	170	1966
25	1926	1880	Borkum - Hortal	Felten & Guillaume	Neptun	German Atl. T.	170	1966
	1928	1340	Bay Roberts - Horta	Tel Con & Maint.	Colonia	Western Union	170	1966

ANNEX 2

INTERCONTINENTAL SUBMARINE CABLES

Major events concerning the introduction of transoceanic intercontinental submarine cable routes for the telephone service]

Main cables year	name	between	Telephone circuit capacity
Transatlantic routes:			
a) *North Atlantic routes:*			
1956	TAT 1	Clarenville, Newfoundland and Oban, Scotland	48 *
1959	TAT 2	Clarenville and Penmarc'h, France	48 *
			* note: no more in service in 1985
1961	CANTAT1	Newfoundland and Oban	80
1963	TAT3	Tuckerton (USA) and Widemouth (UK)	138
1965	TAT4	Tuckerton and St-Hilaire du Riez (F)	138
1970	TAT5	Green Hill (USA) and Conil (Spain)	845
1974	CANTAT2	Widemouth (UK) and Halifax (Canada)	1840
1976	TAT6	Green Hill (USA) and St-Hilaire du Riez (F)	4190
1983	TAT7	Lands End (UK) and Tuckerton (USA)	4200
1988	TAT8	USA-UK-France (optical fiber cable)	16000
b) *South Atlantic routes:*			
1969	SAT 1	Portugal–South Africa	360
	(Greenland)	(with a UK–Portugal extension)	640
1973	Bracan	Brazil–Canary Islands	160
1977	Columbus*	Venezuela–Canary Islands	1240
1982	Atlantis	Portugal–Dakar (Senegal	2580
		+ Dakar–Recife (Brazil)	1380
		+ Dakar–Abidjan–Lagos	
c) *Transpacific routes:*			
1957	Hawaii 1	Honolulu–California	51
1963	Compac	Vancouver (Canada) and Australia + New Zealand via Hawaii and Fiji	* no more in service in 1985
1964	Hawaii	(see Hawaii 1)	143
1964	TPC 1	Hawaii and Tokyo + Manila	143
197x	Seacom	Guam–Hongkong and Singapore	
1974	Hawaii 3	(see Hawaii 1)	845
1975	TPC 2	(see TPC 1)	845
1984	Anzcan	Canada and Australia + New Zealand	
1986	TPC 3	(see TPC 1)	3780
d) *Indian Ocean route:*			
1984–1986	Sea-Me-We	South-East Asia, Middle-East, Western Europe	1080 2580
e) *Other routes:*			
Plus a dozen (or more) of submarine cables criss-crossing:			
– the Mediterranean sea (the first laid in 1961)			
– the Caribbean area (the first laid in 1963)			

In April 1989, the first optical-fiber cable to cross the Pacific Ocean and link the United States and Japan went into service. Providing 40,000 circuits, it was a US $700 million joint-venture of 30 telecommunication companies, the largest being the American AT&T and the Japanese KDD.