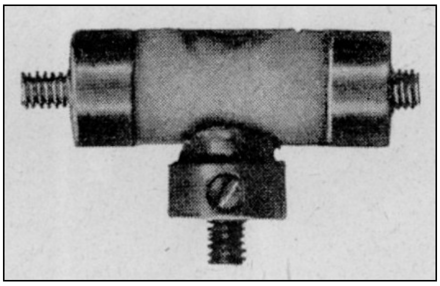
The First French Germanium Semiconductors

CFS WESTINGHOUSE WESTECTAL DIODES AND THE WESTCREL TRANSISTRON

COMPAGNIE DES FREINS ET SIGNAUX
WESTINGHOUSE
16, RUE DE LA VILLE L'EVÊQUE - PARIS 8e



Original French version: **Christian Adam** February 2011 (Colmar, France)

C.H.C.R. & Radiomuseum.org

English translation and text adaptation: **Mark Burgess** (Auckland, New Zealand)

Author's Note

After starting a research project on the history of the first transistors in France [ADAM 08], I discovered the remarkable history of the Transistron, the French point-contact transistor developed by two German scientists, Drs Mataré and Welker. [ADAM 09] and [ADAM 10]

During this work I got in touch with Mark Burgess of New Zealand, an early transistor enthusiast, who has published a good overview of the history of French transistors on his website. [BUR] We agreed to collaborate on an English translation of the original French text allowing access to a wider audience for this paper.

Curiously this story has been brought back to centre stage by German, Belgian and US historians. But I wished to trace this epic from French publications of the time. So I began to collect documentation and components that would help bring the historical facts to life.

Therefore I acknowledge and thank my colleagues from the French C.H.C.R (Club Histoire et Collection Radio) and Radiomuseum for their great support.

Andrew Wylie (GB) provided me with numerous digital photos for this article. The Fédération des Equipes Bull (F) permitted me to photograph its Transistron and publish those photos. Finally, many thanks to Dr Mataré for his correspondence and further information.

This new article - the first in English - brings new unpublished information and also for the first time, details of the Westectal diodes, contemporaries of the Westcrel Transistron.

I would appreciate any additional information, documents or samples on the whereabouts or other similar components by email to:

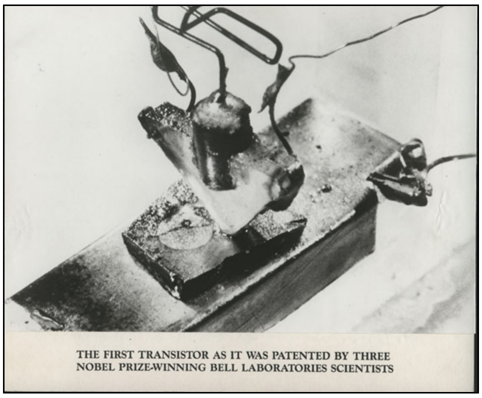
chcr.adam @wanadoo.fr

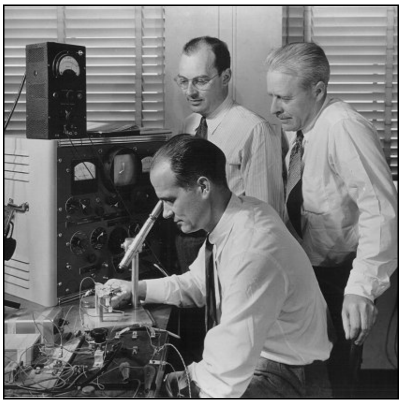
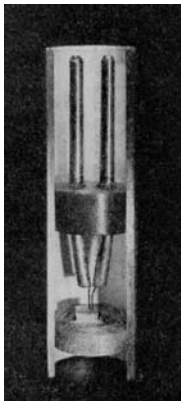
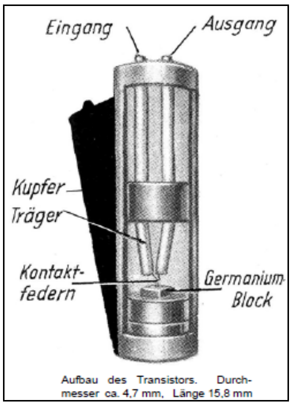
Christian ADAM

1) THE USA INVENTION OF THE POINT-CONTACT TRANSISTOR (1947) AND JUNCTION TRANSISTOR (1948)

December 23rd 1947: Two scientists at Bell Laboratories, John Bardeen and Walter Brattain, show their supervisor, William Shockley, the first point-contact transistor having kept it secret for several weeks. This demonstrated that if two metal contacts are arranged sufficiently closely to one another (less than 50 microns) making contact on a block of purified germanium and properly polarized, the current in one affects the current in the other. A solid state amplifier has been discovered competing with vacuum tubes. The name “transistor” comes from the contraction TRANSfer resISTOR, suggested by JR Pierce in 1948.

While William Shockley celebrated this Christmas gift he was extremely disappointed. He had not been directly associated with the discovery of the device which had been the object of his research for many years. He was frustrated with his staff and applied himself to exceed them. In the weeks that followed, he conceived the junction transistor based on combining three layers of germanium appropriately doped. It was expected that this would be more reliable and more easily industrialized than its point-contact predecessor.



Photos Left to Right: The first point-contact transistor, its inventors, the Bell Type A (first production type, photo from [I&T 49 06]) and an illustration from the German media [FT48]

The inventions were kept secret for six months to allow time to file patents: June 17th for the point-contact transistor and June 26th for the junction transistor. Then on June 30th 1948 the invention of the transistor was made public through a media event in New York. [RIO 97] It went almost unnoticed in the mainstream press because journalists struggled to imagine the tremendous progress in electronics that the transistor would launch. Only the New York Times mentioned it in a very short paragraph on page 46 of its July 1st edition. [DUP 07]

Patented Oct. 3, 1950 2,524,035

UNITED STATES PATENT OFFICE

2,524,035

THREE-ELECTRODE CIRCUIT ELEMENT UTILIZING SEMICONDUCTIVE MATERIALS

John Bardeen, Summit, and Walter H. Brattain, Morristown, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 17, 1948, Serial No. 33,466

40 Claims. (Cl. 179—171)

Excerpt of the Bell Laboratories’ patent of June 17th 1948 for the point-contact transistor. (Bardeen and Brattain inventors)

Patented Sept. 25, 1951 2,569,347

UNITED STATES PATENT OFFICE

2,569,347

CIRCUIT ELEMENT UTILIZING SEMICONDUCTIVE MATERIAL

William Shockley, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 26, 1948, Serial No. 35,423

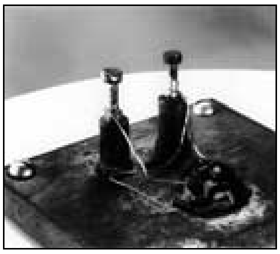
34 Claims. (Cl. 332—52)

Excerpt from Bell Laboratories patent June 26th 1948 for the junction transistor (Shockley inventor)

In France, Eugene Aisberg broke the news in the September 1948 issue of his magazine *Toute la Radio*, the first to do so in the European electronics press. [TLR 49 08] In Germany *Radio Technik* N°10 carried the news and *Funk-Technik* published a very informative article [FT 48] which included the schematic of an 11 transistor superheterodyne receiver. The author cited *Toute la Radio* amongst its sources.

Cover of Toute la Radio N°128 of September 1948 which announced the invention of the transistor in France

The discovery of the point-contact transistor disrupted the relationship between the three men. Shockley, the visionary, was impatient to see more progress made on the junction transistor. While a crude prototype was produced in 1949 it took until April 1950 to make the first grown junction transistor and until the middle of 1951 to demonstrate a transistor with viable audio frequency performance. [RIO 97]



First functional prototype of the junction transistor (1949)

The invention of the transistor was no chance discovery. Since the 1900s galena, iron pyrites and zincite had been used to detect radio waves. In 1926 Julius Lilienfeld tried to make a field effect transistor and describe it theoretically but failed. [DUP 07] Semiconductor technology through to the 1930s remained a limited empirical science.

The period 1931-1940 saw the beginning of theoretical solid state research worldwide. In 1933 the US company Westinghouse released its copper oxide detector, the Westector, which could replace vacuum tube detectors. Below is a French advertisement of its dual detector. Note the name of its subsidiary in France is Compagnie des Freins Westinghouse which later became Compagnie des Freins et Signaux Westinghouse (CFS Westinghouse). It was destined to play an important role.

Advertisement for the Westector in the Magazine Radio REF (Réseau des Emetteurs Français) August 1933 (Author's Collection)

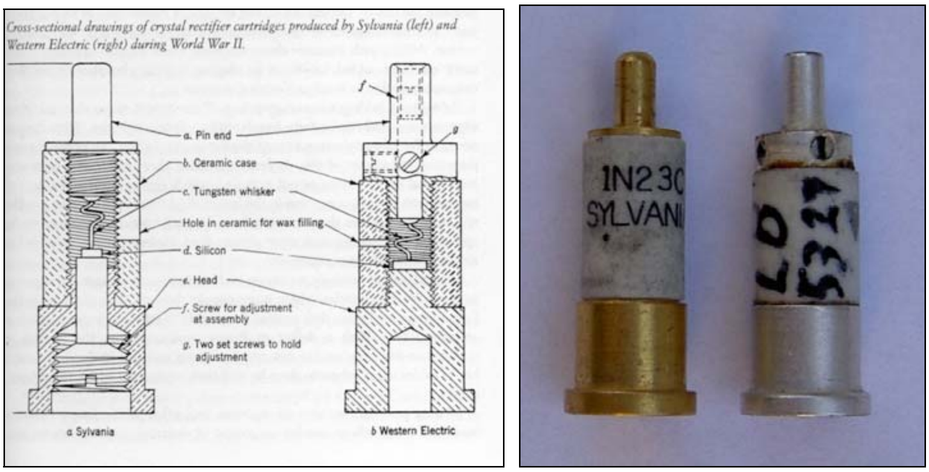
COMPAGNIE
DES
FREINS WESTINGHOUSE

Letter head of CFS Westinghouse (Author's Collection)

In the United States, research was undertaken from 1942 to develop reliable silicon and germanium diodes able to withstand the high back voltages required by radar. In Germany researchers pursued similar objectives before and during the War.

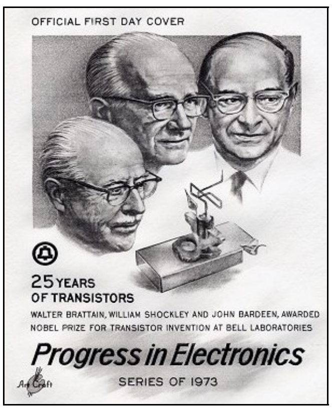
In the United States, silicon diodes such as the 1N21 for military use in radar (low noise and very high frequencies) were produced commercially in the millions during the Second World War.

Western Electric 1N21 diode February 17th 1944. Note the protective lead capsule.
Western Electric was the commercialization company of Bell Laboratories
(Author's Collection)



Design differences between the military diodes of Sylvania and Western Electric.
LHS-sectional view (image from [RIO 97]), RHS photo of the Sylvania1N23C and the Western Electric 1N21
(Author's Collection)

The three American scientists John Bardeen, Walter Brattain and William Schockley received the Nobel Prize in 1956 for their work. They were the first to demonstrate a point-contact and junction transistor and were therefore catalysed the global semiconductors industry. But researchers in other countries had not been inactive, even if their work was eclipsed by the team at Bell Laboratories.



The Nobel Prize Laureates in Physics for 1956

2) COMMENCEMENT OF THE FRENCH SEMICONDUCTOR INDUSTRY

In post liberation France, Henri Jannès, director of CNET (Centre National d'Etudes des Télécommunications created on May 4th 1944) made the gloomy observation: "French technology, with respect to the manufacture of miniature and special tubes, is ten years behind American technology." [DUP 07] France had not anticipated the impact of semiconductors. It had not invested in research on solid state components that would supplement tubes as had Germany and the United States.

After the war silicon and germanium detectors recovered from German and American military equipment were studied at SRCT (Service des Recherches et du Contrôle Technique), the research department of the Ministry of Post and Telecomunications. Its director was then Pierre Marzin. Their interest was in telecommunications networks.

As in many domains, German experts strengthened the scientific teams of the victorious countries postwar. The French arrived in 1946 to convince two German semiconductor research specialists to come to France to continue their wartime work. [DUP 07] Like other scientists they were debriefed by allied intelligence services. [HAN 99] We have to remember the devastation of Germany in 1946 to understand how the proposal for scientists to work in France could represent a real opportunity, both for their careers, but also simply to survive the difficulties of daily life in occupied Germany.

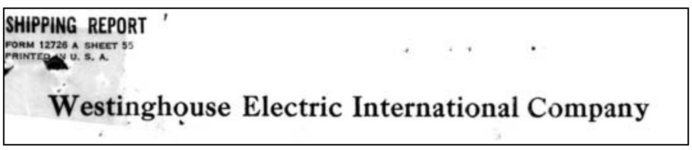
Photos left to right: Pierre Marzin, Director of the SRCT
Herbert Franz Mataré (1948) , Heinrich Johann Welker (photo Siemens)

Dr Herbert Franz Mataré was born in 1912. He studied in Geneva, Switzerland, where he learned French, and then in the well known University of Aachen. In 1939 he joined the Telefunken Berlin laboratory where he obtained his PhD in 1944. During the war he worked on improved centimetre band reception developing the duo-diode with the objective of reducing noise in radar receivers. After the war he became a teacher at a military academy before agreeing to move to France starting at CFS Westinghouse in early 1947.

Dr Heinrich Johann Welker (1912 - 1981) worked with Sommerfeld for his doctorate and published with him important fundamental articles. During the war he worked in aviation radio research including centimetre band crystal detectors and on a three electrode crystal. [HAN 99] In the difficult conditions of post-war Germany, he established himself as an independent engineer and worked in collaboration with Wolfgang Bull, whom he had known as a result of his work on centimetre detectors in 1942. Wolfgang Bull was the founder of a company called Proton that post-war manufactured small numbers of germanium diodes based on his wartime research.

Advertisement for Proton ,from Radiopraktiker 45/46 1952 (Author's Collection)

Early in 1947 Heinrich Welker joined Herbert Mataré at CFS Westinghouse. Originally this company had been owned by the Westinghouse Electric International Company but was now an independent French company. [HAN 99]



1933 Letter head of the Westinghouse Electric International Company (Author's Collection)

3) THE FIRST FRENCH GERMANIUM DIODES: THE WESTECTAL FROM CFS WESTINGHOUSE (1947)

In 1946 CFS Westinghouse applied to SRCT for funding of a study of silicon and germanium detectors as key outputs in the development of semiconductors and their commercial production. [BOT 94] Although at that time the French Air Force had a development contract with French Thomson Houston Company (CFTH), Pierre Marzin and his assistant René Sueur were very receptive to this proposal. CFS Westinghouse was already recognized for its Westector rectifier and detector technology and the funding would allow it to expand its activities into high frequency diodes and detectors.

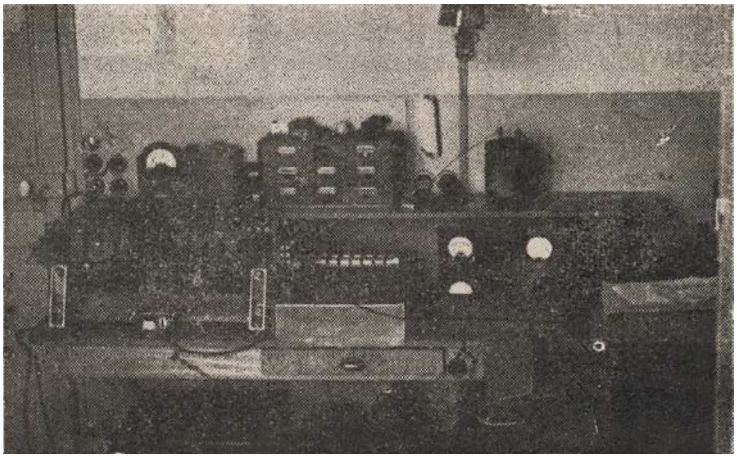
A contract for 6 million francs was approved in December 1946 but given lower priority than tubes contracts, despite the support of the representatives of the Navy. It was approved for commencement in March 1947 although CFS Westinghouse did not wait and began work. [BOT 94] After further administrative delays, the contract was finally signed by the SRCT in November 1947. [LIC 96]

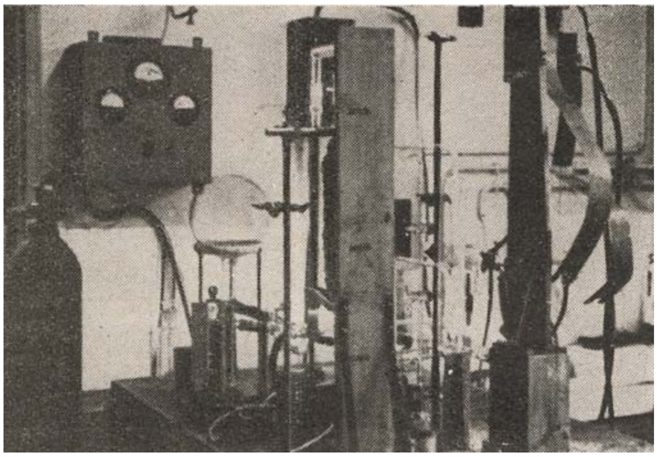
The requirement was to be technically competitive with Sylvania diodes such as the 1N34. [HAN 99] This was the first non-military diode marketed in the United States (1946) and later in 1950 was the first diode produced in a sealed glass envelope as the 1N34A. [WARD]

The First US Commercial Diode, the Sylvania 1N34 [WAR]

Under the leadership of Herbert Mataré CFS Westinghouse created a germanium and silicon laboratory from scratch and separated from its selenium laboratory in order to prevent cross contamination. [BOT 94] Working with Heinrich Welker, their laboratory was established in a small unhabited building at Aulnay-sous-Bois close to Paris. Welker took responsibility for the development of semi-conductor material and Mataré for the production of diodes and their characterisation. [HAN 99]

Thanks to the scientific background of both German specialists, work began quickly in mid-1947. They gave priority to germanium and Welker worked on improved purification techniques (as did Bell Laboratories).



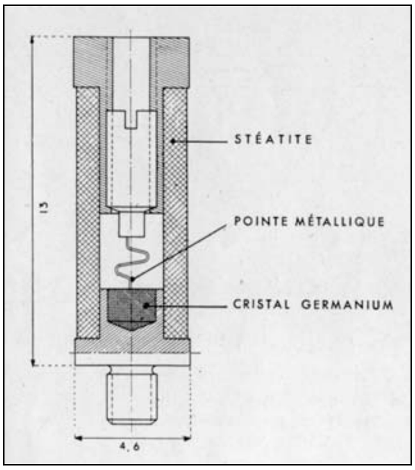


Photos taken from [LOE 49 11]: Equipment used by Drs Mataré and Welker

Left: equipment for measuring the number of free electrons per unit volume from the Hall coefficient
Right: Germanium Processing Facility

By early 1948 three diode types had been developed and a pilot production line capable of producing 3000 diodes per month constructed. By mid 1948 hundreds of diodes and detectors suitable for high frequency radar mixers were being produced and tested by the technical services of the army and laboratories of CNET. They showed excessive spread of characteristics at high frequencies and excessive noise relative to US reference diodes. [BOT 94]

Early 1949 CFS Westinghouse was capable of producing 10 000 to 20 000 diodes and detectors per month with performances good enough to reach 3 cm wavelength (10 GHz). [CFSW 49] The first components were the Westectal WG1 diode and WG2 detector. [CFSW 49 & 51] The “G” stands for germanium and distinguishes them from the Westector W miniature copper oxide diodes. [CFSW 48b]



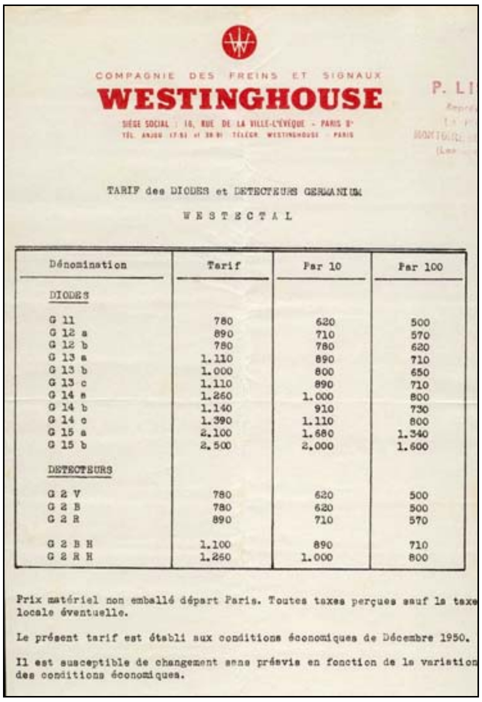
On the left the Westectal WG1, first of the germanium diode series
Right, cutaway view of the cartridge base. [From CFSW 51] (Author's collection)

Left: yellow type C WG1 diode and right: blue WG2 cartridge (with added leads) (Author's collection)

Three types of termination were provided for the same basic cartridge:

- Type A JAN radar cartridge
- Type C solderable
- Type L twin plug cartridge

In its account of the 1950 Paris components Expo, the March-April 1950 edition of "Toute la Radio" [50 TLR 03] reported that CFS Westinghouse germanium diodes were "available for sale." This is confirmed by the CFS Westinghouse price list for December 1950. [CFSW 50]



COMPAGNIE DES FREINS ET SIGNAUX
WESTINGHOUSE
SIÈGE SOCIAL : 16, RUE DE LA VILLE-L'ÉVÊQUE - PARIS 8e

TARIF des DIODES et DETECTEURS GERMANIUM

WESTECTAL

Dénomination	Tarif	Par 10	Par 100
DIODES			
G 11	780	620	500
G 12 a	890	710	570
G 12 b	780	780	620
G 13 a	1.110	890	710
G 13 b	1.000	800	650
G 13 c	1.110	890	710
G 14 a	1.260	1.000	800
G 14 b	1.140	910	730
G 14 c	1.390	1.110	800
G 15 a	2.100	1.680	1.340
G 15 b	2.500	2.000	1.600
DETECTEURS			
G 2 V	780	620	500
G 2 B	780	620	500
G 2 R	890	710	570
G 2 B H	1.100	890	710
G 2 R H	1.260	1.000	800

Prix matériel non emballé départ Paris. Toutes taxes perçues sauf la taxe locale éventuelle.

Le présent tarif est établi aux conditions économiques de Décembre 1950.

Il est susceptible de changement sans préavis en fonction de la variation des conditions économiques.

December 1950 price list of CFSW diodes WG1 and detectors WG2 (Author's collection)

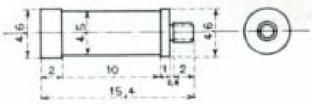
The primary objective of producing French germanium diodes commercially had been achieved! The only competition in France at this time came from CFTH which produced silicon diodes of English design. [BOT 94]

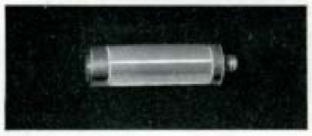
DIODES ET DÉTECTEURS A CRISTAUX
" WESTECTAL "

FEUILLE TECHNIQUE
C. F. S. W. N° 78
JANVIER 1949

CARACTÉRISTIQUES ET ENCOMBREMENT DES "WESTECTAL" A CRISTAL DE GERMANIUM

PRÉSENTATION DE LA CARTOUCHE DE BASE





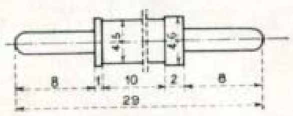
CARACTÉRISTIQUES ÉLECTRIQUES

Emploi	DIODES			DÉTECTEURS		
Code	WG1			WG2		
Teinte repère	JAUNE			VERT	BLEU	ROUGE
Classe	I	II	III			
Fréquences	0 à 300 Mc			0 à 600 Mc	100 à 1000 Mc	100 à 10000 Mc
				50 cm	30 cm à 3 mètre	9 cm à 3 mètre
Caractéristiques en sens direct	I = 25 mA 0·5 < U < 1·5			I = 25 mA 0·6 < U < 1·3	0·7 < U < 0·9	0·4 < U < 0·7
Caractéristiques en sens inversé	10 v i < 1 mA	— 10 v i < 0,3 mA	— 20 v i < 0,3 mA	— 3 v i < 0,3 mA	— 1 v i < 0,3 mA	— 1 v i < 1 mA

MONTAGE

La cartouche de base peut être équipée d'embouts permettant d'obtenir les présentations ci-dessous.

ENFICHAGE DOUBLE
CODE L



FILS A SOUDER
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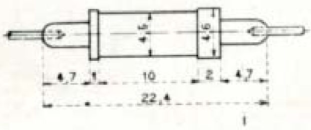
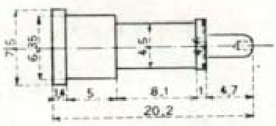


CARTOUCHE
CODE A



Exemples pour passer une commande Détecteur WG2 - Bleu - C
Diode WG1 - II - Jaune - A

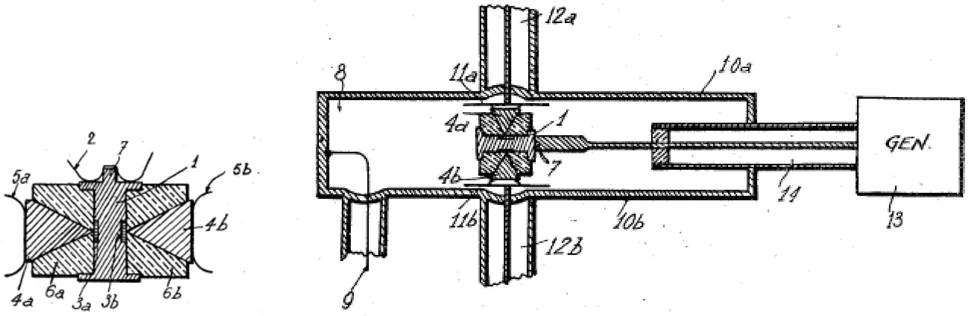
T. S. V. P.

Cie DES FREINS ET SIGNAUX WESTINGHOUSE
SERVICE OXYMÉTAL
16, RUE DE LA VILLE-L'ÉVÊQUE - PARIS (8e) — ANJou 17-51 (4 lignes)

Data Sheet for the Westectal WG1 diode and WG2 detector [from CFSW 49] (Author's collection)
Note the colour coding for frequency range.

4) THE FIRST FRENCH AND EUROPEAN TRANSISTOR: THE TRANSISTRON OF MATARE AND WELKER (1948)

When the opportunity allowed, Mataré resumed the work he started in Germany during the war on the UHF duo-diode. A French patent was filed on the 23rd of May 1947. [CSFW 47] The duo-diode had two point-contacts on the same germanium crystal intended to reduce background noise by subtracting the noise at one electrode from the noise signal of the other. During his wartime experiments in Germany, Mataré had noticed an interaction between the two signals.



Figures from the UHF duo-diode patent filed by H. Mataré on 23rd May 1947 [CSFW 47]

Early 1948, a little after Bell Laboratories' discovery, he managed to control the current in one diode from the other, with two point contacts up to 100µ apart which Welker sought to interpret with the theory of Schottky. [HAN 99] They had independently discovered a solid state amplifier; a point-contact transistor, without the benefit of the Bell Laboratories work which was still confidential. The independence of their invention is now generally accepted. [RIO 05, MAR 03] Even in its time the independence of the invention was not challenged. For example, Aisberg wrote: "So, until proven otherwise, we should accept that the discovery of the germanium triode has been accomplished in the laboratory of PTT in parallel with the American research." [TLR 49 08] Note that as the funder, the PTT took the credit for the CFS Westinghouse discovery.

Acting urgently after the June 30th 1948 revelation of the Bell Laboratories' transistor, Mataré and Welker filed a patent in France on August 13th 1948 [CFSW 48a] for their "Transistron," based on their work for CFS Westinghouse. Their patent was filed in preparation for a patent dispute that seemed inevitable at that time.

RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE L'INDUSTRIE ET DU COMMERCE

SERVICE de la PROPRIÉTÉ INDUSTRIELLE

BREVET D'INVENTION

Gr. 12. — Cl. 6. N° 1.010.427

Nouveau système cristallin à plusieurs électrodes réalisant des effets de relais électroniques.

Société anonyme dite : COMPAGNIE DES FREINS ET SIGNAUX WESTINGHOUSE résidant en France (Seine).

Demandé le 13 août 1948, à 15h 44m, à Paris.

Délivré le 26 mars 1952. — Publié le 11 juin 1952.

Heading of the Transistron patent, inventers Drs Welker and Mataré [C.S.F.W. 48a]

The "Transistron" was nothing less than the European version of the point contact transistor whose name had been subtly changed by René Sueur to stand out from the American word "transistor." [LOE 49 11] The photo below shows its first form from June 1948.

First European transistor constructed in June, 1948 at the Semiconductor Laboratory of F & S Westinghouse in Paris, France by H. F. Mataré

First European transistor constructed in June 1948 at the Semiconductor Laboratory of CFS Westinghouse in Paris, by H F Mataré and H Welker (source: Deutsches Museum [SPI 08])
Note the similarity with the Bell type A

In December 1948, a dozen of these "French amplifying triodes" were available for research and testing. Their existence remained confidential. [BOT 94]

Further work on Transistron was funded under a second contract worth seven million francs with final approval in May 1949 by the the PTT who wanted it to replace tube relay amplifiers in telephone exchanges which were far too power hungry. [DOR 04] This objective meant work on high frequency devices.

Despite the secrecy, the existence of a French transistor reached Bell Laboratories in 1949. Alan Holden was detailed to visit the Aulnay-sous-Bois laboratory during his trip to England. He wrote in a letter dated May 14th 1949 to Shockley "As we arrived, they were transmitting to a little portable radio receiver outdoors from a transmitter indoors, which they said was modulated by a transistor. This PTT bunch in Paris seems very good to me. They have little groups in all sorts of rat holes, farm houses, cheese factories and jails in the Paris suburbs. They are all young and eager." (Cited by Riordan [RIO 05])

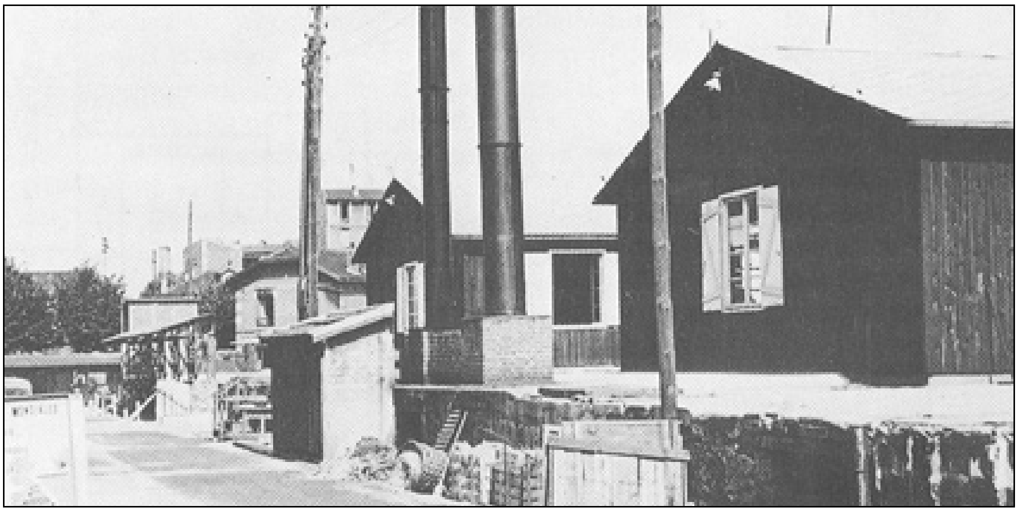
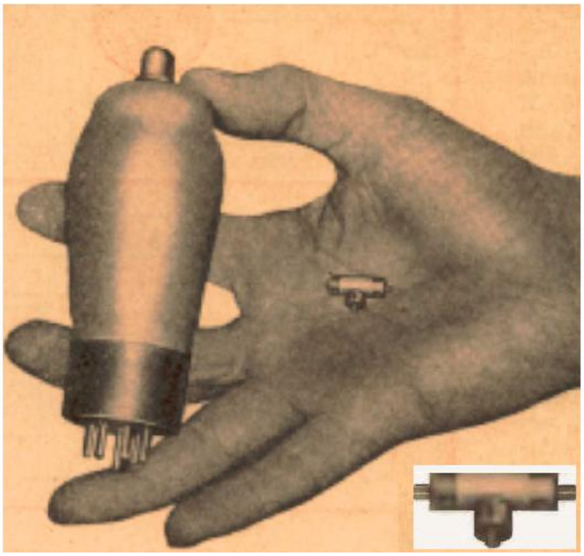
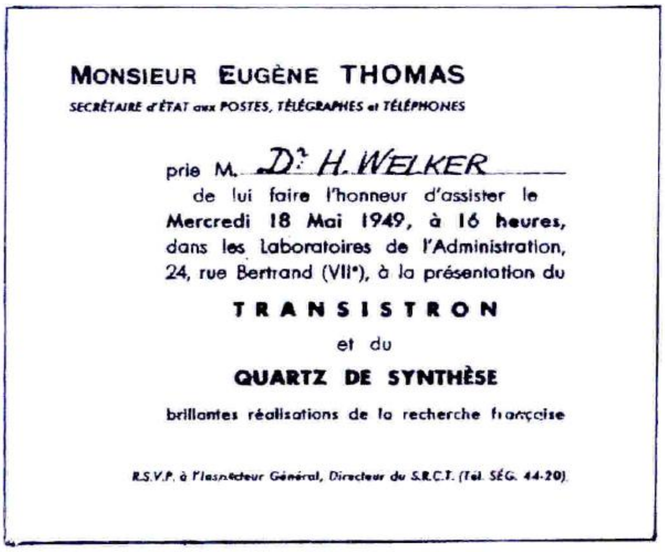


Photo from 1948 showing CNET-SRCT buildings in the suburb of Paris illustrating the adverse situation in France immediately post-war [DUP 07]

This "French" invention (more correctly “Franco-German” because the work of the two German researchers started in Germany before and during the War) was publicly launched on May 18th 1949, four days after visit of Bell Laboratories. It was justifiably described by the authorities as a "brilliant achievement of French research." The information was a classified defense secret before that date. The official launch of the Transistron was similar to the event that Bell Laboratories arranged for their launch of the point-contact transistor on June 30th 1948.

All the technical press was not invited to the launch, to the annoyance of Eugene Aisberg, editor of the magazine *Toute la Radio* who described it angrily in his article *Transistron = transistor +?* published in August 1949. [TLR 49 08] The news was released by way of the daily media, Combat featuring a photo of the Secretary of State for PTT, Eugene Thomas, holding a tube and the new Transistron in his hand:





MONSIEUR EUGÈNE THOMAS
SECRÉTAIRE d'ÉTAT aux POSTES, TÉLÉGRAPHES et TÉLÉPHONES

prie M. Dr H. WELKER
de lui faire l'honneur d'assister le
Mercredi 18 Mai 1949, à 16 heures,
dans les Laboratoires de l'Administration,
24, rue Bertrand (VII°), à la présentation du

TRANSISTRON

et du

QUARTZ DE SYNTHÈSE

brillantes réalisations de la recherche française

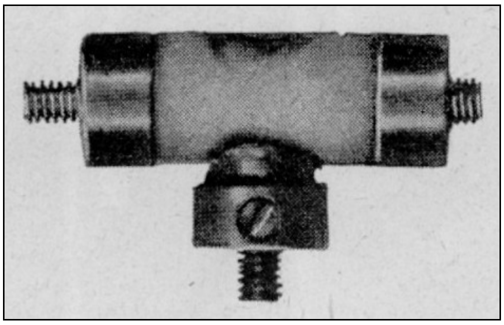
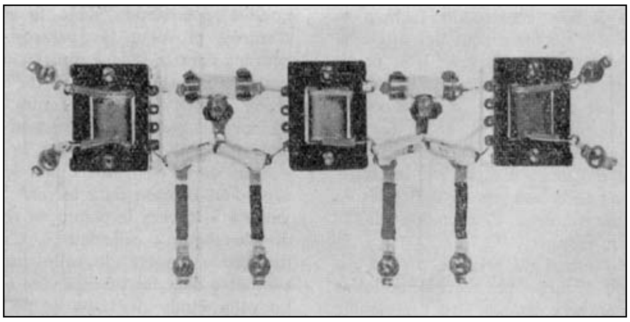
R.S.V.P. à l'Inspecteur Général, Directeur du S.R.C.T. (Tél. SÉG. 44-20)

The Transistron shown in comparison with a tube made by SIF for PTT [TLR 49 08] with insert of the Transistron from the same image and the invitation to the official launch of the Transistron to Dr Welker (From [DOR 04])

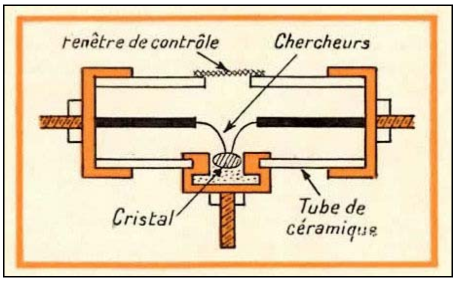
Transistor et Transistron by H Aberdam is the earliest technical article we have been able to find announcing the

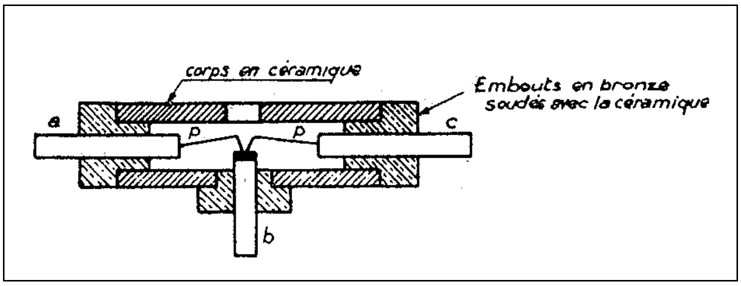
Transistron. It was published in the June 1949 edition of Ingénieurs et Techniciens and dedicates six pages to the American and French developments. For the Transistron only Drs Welker and Mataré are mentioned along with SRCT and CFS Westinghouse. [I&T 49 06] The published characteristics for the 1949 Transistron are:

Power gain:	*100 (20 dB) in ideal conditions*
Power output max:	*25 mW*
Power consumption:	*100 mW*
Efficiency	*25%*
Frequency max :	*Up to 10MHz*

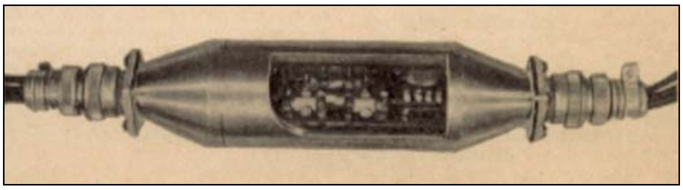
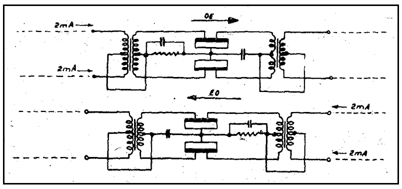
The 1949 Transistron (Body L = 16 mm D = 6 mm) and an innovative circuit on a Plexiglas Base [I&T 49 06]



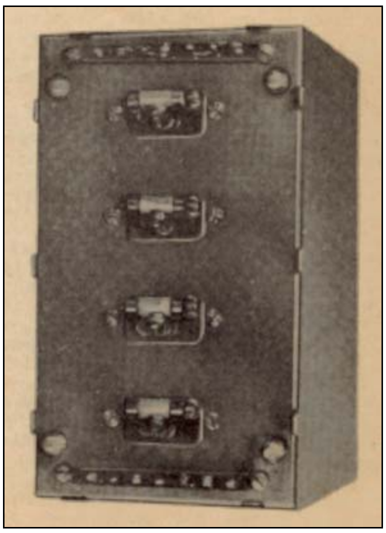


Diagramatic cross sections of the 1949 Transistron [TLR 49 08] left and [LOE 49 11] on the right. Note the presence of a window that allowed positioning of the point-contacts on the germanium

The public launch of the " PTT 601 Transistron triode" showed some devices using the new solid state amplifier: a radio receiver, a transmitter, and telephone repeaters illustrated in [LOE 49 11] and [TLR 49 08] shown below.

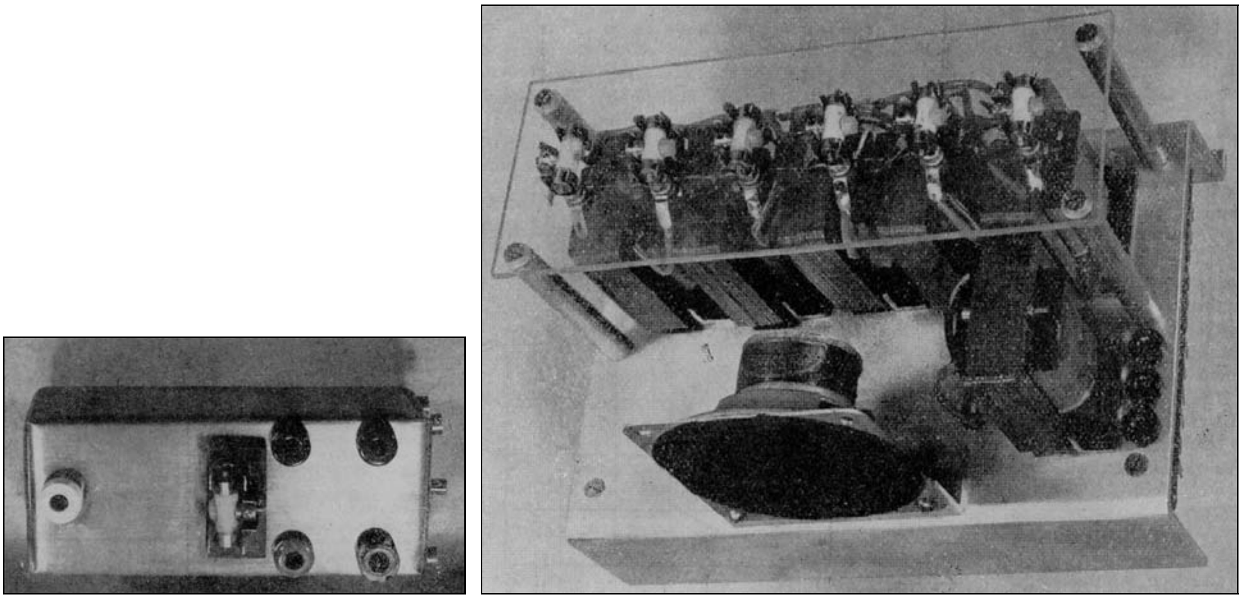



In line self powered two Transitron Repeater [TLR 49 08] with its schematic [LOE 49 11]



Four Transitron Telephone Repeater. Gain 45dB, 40 to 10 000 Hz [TLR 49 08]

The one Transistron transmitter and six Transistron receiver are almost certainly the ones mentioned by Alan Holden:



One Transistron Long wave Transmitter (300m) and six Transistron Receiver [I&T 49 06]

The article *Le Transistron Triode Type P.T.T. 601* written by René Sueur appeared in the November 1949 issue of the journal L'Onde Electrique is an important reference article on Transistron. Sueur cites American work in his references and details the members of the small team of CFS Westinghouse:

Welker	Senior Researcher
Mataré	Senior Researcher
Petit-Ledu	Physicist
Bethge	Engineer
Poilleaux	Technician
Calon	Technician
Philippoteaux	Technician

At this time the Technical Director of CFS Westinghouse was M Engel. [LOE 49 11]

Despites the difficult post-war conditions, limited quantities were produced from early 1949 and delivered to the PTT for internal use. The first practical objective was to equip the phone line from Paris to Limoges with Transistron repeaters. [TLR 49 08]

The first commercial version of the Transistron no longer features the adjustable base contact used earlier to help align the point-contacts. Its ceramic body construction is very similar to the Westectal cartridge diode:

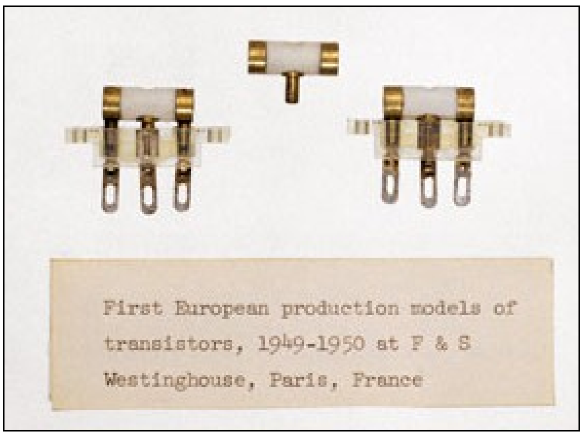
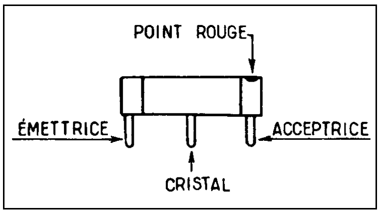


Photo of the Transistron 1949-50 Production Version (source Deutsches Museum [SPI 08])

This version closely follows the form given in [TLR 52 05] shown below. Note the early French names of the electrodes: Emettrice (emitter) Cristal (base) and Acceptrice (collector)



Drawing of the Transistron [TLR 52 05]

CFS Westinghouse produced 1000 Transistrons in the first half of 1949. [BOT 94, HAN 99] At this time Bell Laboratories had produced the 3700 type A transistors of which 2700 had been distributed to other companies, military agencies and some universities. [RIO 97] Thus both countries were advancing in a comparable manner. René Sueur announced mass production by November 1949. [LOE 49 11] The Transistron production line was to be at the CFS Westinghouse factory at Sevran-Freinville, a few kilometers from the laboratory of Aulnay. This is the plant which produced the famous Westinghouse automatic brake for trains, one of the flagship products of the company (hence the name of the location). This choice of location enabled CFS Westinghouse to consolidate the existing production of metal oxide rectifiers with the new Transistron line.


ÉTABLISSEMENTS DE FREINVILLE
SEVRAN (S.-&-O.)

Excerpt from the book "The Westinghouse Automatic Brake for Freight Trains "
(Author's collection)

On the left, the metal oxide rectifier factory and assembly hall (date unknown, Author's collection)
On the right : postcard showing the plant Freinville in 1968

In its coverage of the 1950 Paris components Expo, *Toute la Radio* for March-April 1950 [TLR 50 03] reported: "As for the famous Transistron triode (to be called "Westcrel") the management have promised delivery by1950."

In the same year Brattain and Shockley visited the Paris laboratory of CFS Westinghouse as part of a visit to England. Mataré made a phone call to Algiers for them, demonstrating a line equipped with Transistron repeaters. He remembers that Shockley was impressed [RIO 05] because the Bell transistor of the time did not allow such use at high frequencies.

Riordan has noted that Bell Laboratories were having technical difficulties and that mid 1949 their Type A point-contact transistors were “...much noisier than equivalent vacuum tubes, and they had serious limitations in power output and frequency range. What’s worse, their performance characteristics differed substantially from one unit to the next. For example, the current gain at the collector varied by as much as 50% in a single batch coming off the production line.” [RIO 97]

In 1951Jack Morton noted in the introduction to *The Transistor*, produced for the 1951 Bell transistor symposium, that the transistor was a neither reliable nor reproducible device when first introduced. [MOR 51] For example, in

September 1949 Bell measured a huge variation in frequency cut off (gain 3dB down) of 30:1 but production improvements by February 1951 had reduced this to ±20%. [BELL 51]

Dr Mataré confirms the frequency superiority of the Transistron [MAT 09] in his email dated 1rst of December 2009: *"The importance of higher frequency response was clear to me, as I was a high-frequency specialist (see my book on receiver problems in the hyperfrequency domain from 1950, at Oldenbourg). Dr.Welker was more the crystal specialist who worked on superconductivity and later III-V-compound semiconductors which have grown to be all important. But he, as Bardeen, did not see that these high input capacities were killing the frequency response. That one had to keep the emittor at low impedance was clear from the beginning, when in 1947 I designed a duodiode for radar mixers with two whiskers, a forerunner of the transistron. Our later production was built on measuring test-sets for high-frequency response."*

5) THE ANNOUNCEMENT OF THE AMERICAN JUNCTION TRANSISTOR (1951)

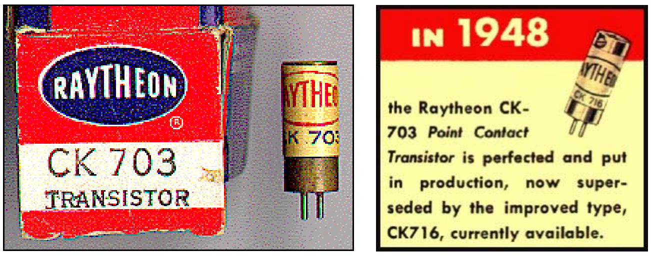
Yet despite the good results obtained, the outlook was bleak for the French team. According to Mataré the anticipation of the Bell patents and priority for nuclear research caused SRCT to cease funding contracts for CFS Westinghouse's work on the Transistron.

The truth is more complex: the United States had again taken leadership. On July 4th 1951 Bell Laboratories held a press conference to announce that they had resolved the recurring technical problems of the point-contact transistor. [RIO 97] By controlling the purity of mono-crystalline germanium they had solved the problems of excessive variation in the characteristics and reliability of the first transistors.

But of more significance was the revelation of the Shockley junction transistor at the same press conference. This new transistor was more reliable and much more energy efficient than its predecessor; ideal for the computer industry that was just emerging. Furthermore, the junction transistor was easier to manufacture. After only three years the new point-contact transistor was in danger of obsolescence!

From 17th to 21st September 1951 Bell Laboratories ran a symposium on the transistor to increase the national interest in this new component in order to accelerate applications development. They announced that Western Electric would produce the point-contact transistor from the fall and that samples of junction transistors were available directly from Bell Laboratories for research.

Another US company, Raytheon, was already a serious competitor. It had commercialized the point contact transistor with its first model, the CK703, available primarily for applications research from late 1948. Its successor, the CK716 was distributed more widely in 1950. And it would also quickly commercialise the junction transistor sampling the CK718 from late 1952.



The CK703 from Raytheon : the first point-contact transistor commercialized in the United States [WYL] and its successor the CK716

When the junction transistor patent issued on September 25th 1951, Western Electric began to grant licenses for the relatively modest sum of $25,000 enabling small companies such as Texas Instruments and Sony to be amongst the licensees and to make good use of the technology as their histories show. This was precisely the objective: the transfer of the technology worldwide at an affordable price to accelerate new developments globally. The goal was to create a vibrant world around the transistor and to challenge the powerful vacuum tube industry whose engineers saw the transistor as a laboratory curiosity without an industrial future.

It seems, however, that SRCT had its own agenda that was independent of the nascent globalisation of semiconductors and indeed, CFS Westinghouse. SCRT chose to proceed in-house continuing the focus on the point-contact transistor. Its director, Pierre Marzin wanted to restrict the second CFS Westinghouse Transistron contract to academic research to address the variability of the Transistron's gain. However, investing in fundamental research as well as in the dedicated equipment required was seen by the management of CFS Westinghouse as an additional delay on its return on investment. At a stormy meeting in the first half of 1951 the CFS Westinghouse contract was terminated by mutual agreement. Consequently the lab of Aulnay-sous-Bois was closed. [LIC 96]

Following this decision, the two German scientists left France: Welker returned to his homeland, Germany in 1951 to work for Siemens Erlangen where he held prominent positions ending as the head of the Siemens research labs. Mataré followed in 1952 and with businessman Michael Jacob founded the Intermetall company in Germany to produce diodes and then transistors. [ADAM 10]

6) THE RISE AND FALL OF THE TRANSISTRON (1952-1954)

The Transistron epic continued within CFS Westinghouse but without its parents. *TSF & TV* magazine for March 1952 [TSF 52 03] reported the news of the Paris components Expo. On their stand Westinghouse exhibited a "receiver without electron tubes, but only transistors... This regenerative detector radio contained only four transistors and yet drove a loudspeaker." A photo sensationalising the set was published in the March-April (No. 164) edition of *Toute la Radio*.

Une des sensations du Salon de la Pièce Détachée : récepteur à quatre transistors et redresseur oxymétal fonctionnant en haut-parleur et réalisé par Westinghouse.

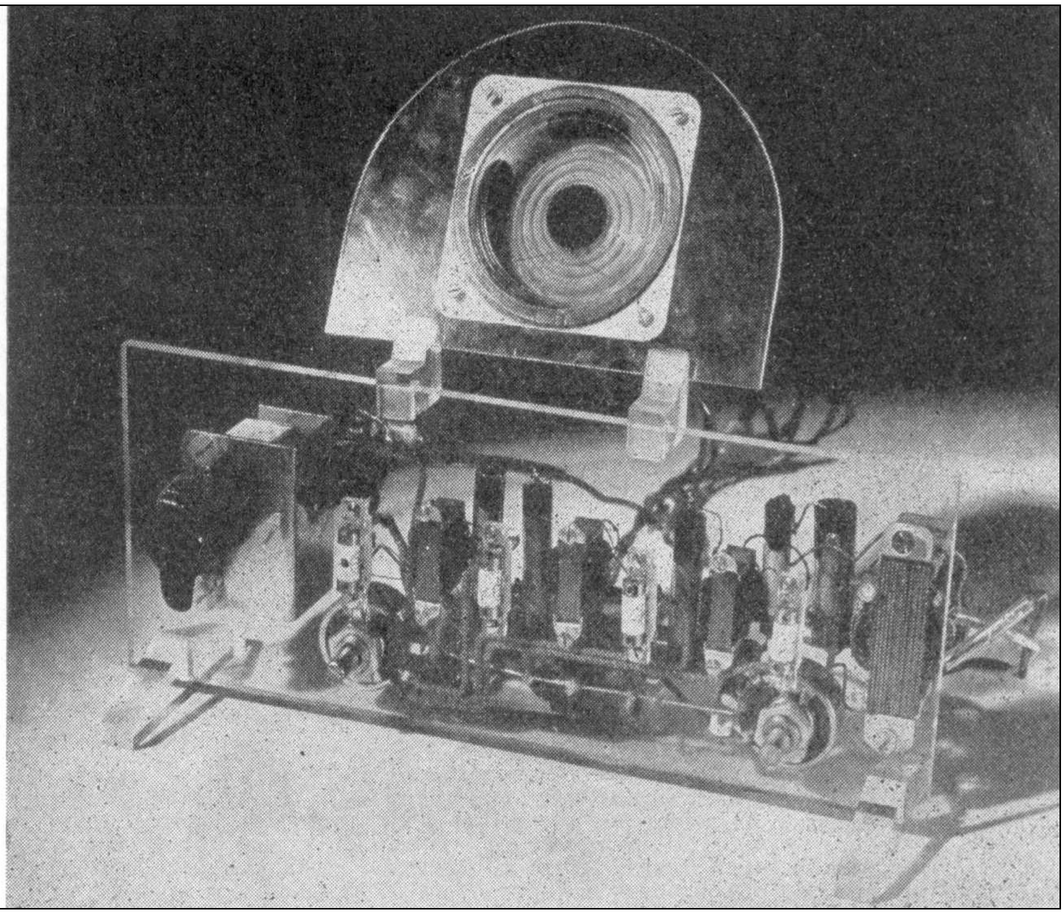
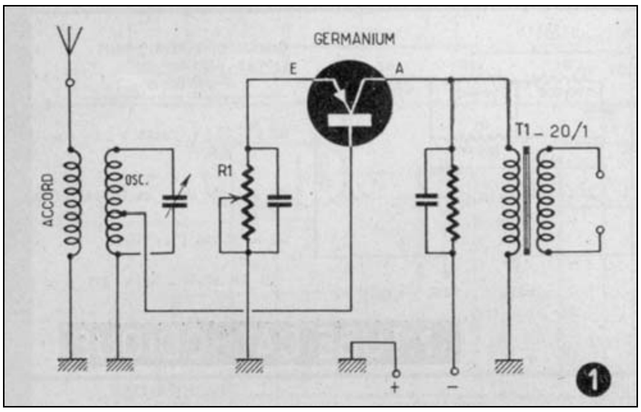
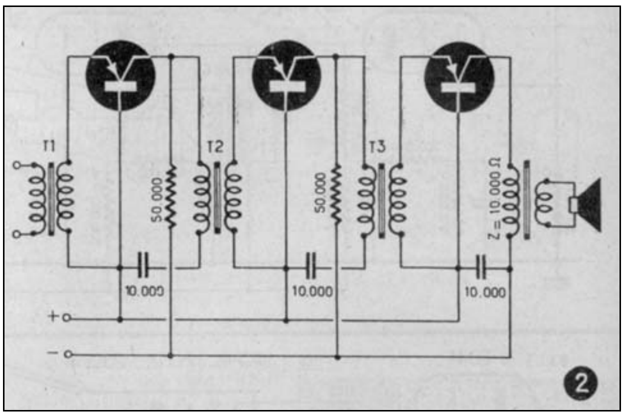


Photo of the Westinghouse Four Transistron Set [TLR 52 03] "One of the sensations of the components Expo: a receiver with four transistors and a metal oxide rectifier driving a speaker by Westinghouse."

In the following edition of the same journal an article entitled "The WestinghouseTransistor Receiver" appears by Mr. Calon from R & D research services of CFS Westinghouse. He describes this set referring to four "Westcrel N transistors" which are actually Transistrons. Note that the term "Transistron" has fizzled and the US term "transistor" prevails now. The following schematic illustrates the design of the set:





HF Stage *AF Stage*

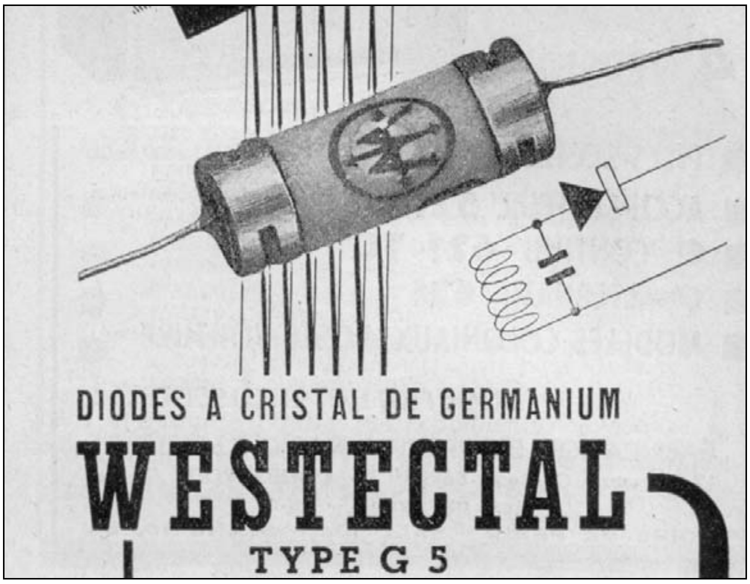
Schematic of the CFS Westinghouse Set [TLR 52 05]

The power supply used a Westalite selenium rectifier and conventional filtering providing 15ma at 100 V. The first Transistron was the detector and the following three provided audio amplification with 300 mW to the loudspeaker. The sensitivity was excellent: tuning the main European stations on an indoor antenna.


Westalite Y8 single selenium rectifier for high tension (125V 35 mA)
Author's Collection (model June 1956)

Note that the first radio demonstrated by Westinghouse in 1949 required six Transistrons. The article emphasizes the interchangeability of the four Transistrons, demonstrating the reproducibility of their manufacture.

Also in the same edition of Toute la Radio 1952 the Westectal type G5 germanium diode for use up to 400 MHz with voltage to 200V was advertised. This featured new outline that simplified production.



New form of Germanium Diode Westectal G5 [TLR 52 05]
Note the resemblance to the 1N34 from Sylvania

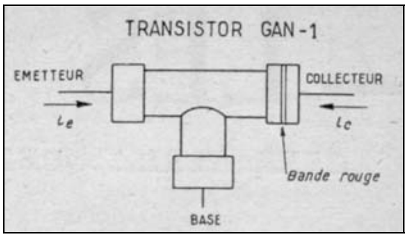
And to conclude this eventful year for the Transistron he became a transatlantic guest of MIT joining their transistor evaluation programme as indicated from this index of reports:

Transistor Measurements & Specifications

M-1404	N.T. Jones	TRANSISTOR GROUP EXPERIMENTAL PROCEDURES
M-1541	N.T. Jones	BRIEF DESCRIPTION OF TRANSISTOR TYPES
M-1540-1	J.F. Jacobs	NOTES ON THE SPECIFICATIONS OF THE RCA TA-165
M-1610	N. T. Jones	EVALUATION OF SAMPLE FRENCH WESTCREL TRANSISTORS
M-1620	N.T. Jones	INTERPRETATION OF TRANSISTOR DATA CARDS

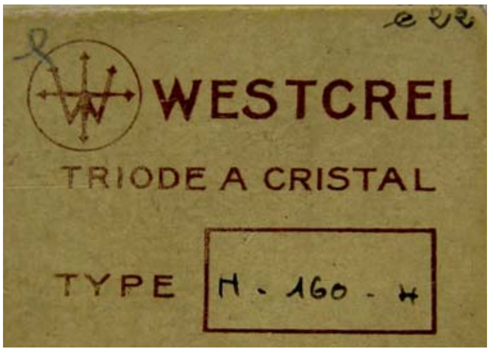
Extract from the index [MIT 52] showing that MIT tested the Westcrel Transistron

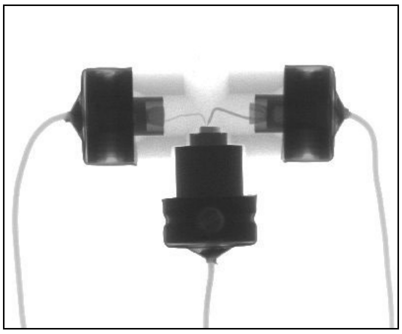
In 1953 five pages are devoted to a transistor article by J P Oehmichen in [TLR 53 07] It documents measurements made by the author on just one transistor: the Westinghouse GAN-1 "crystal triode."



Description of the Westinghouse GAN-1 [TLR 53 07]
Dimensions: Diameter 6 mm Length 17mm

The Westcrel GAN -1 Transistron had a new outline following the style of the type G5 diodes illustrated above and matching surviving examples of the Transistron held by collectors shown below:





Photos of known Westcrel type N Transistrons (later type GAN-1)
Top :Type N 160 H from FEB collection [FEB 08] (photo by author)
Bottom :Its X-Ray image clearly showing the arrangement of the point-contacts (collection Andrew Wylie [WYL])

The article by JP Oehmichen [TLR 53 07] sets out the characteristics (typical values) of the Westcrel Transistron GAN-1 representing its final state of development:

Maximum Values :

- *Collector voltage* *40 V*
- *Collector current* *10 mA*
- *Power* *100 mW*
- *Emitter current* *3mA*

Gain :

- *Current gain* *2*
- *Power gain* *16dB*

Frequency Performance :

Useful RF gain *0.5-2.0 Mhz*
Frequency max *10 Mhz*

Impedance Matching :

- *Input* *110 Ω*
- *Output* *5500 Ω*

Like all the leading corporates in the field of transistors, CFS Westinghouse did not appear to have understood the significance of its invention. In its Annual Report for the financial 1952 year the Transistron is not mentioned among the new developments undertaken. [CFSW 53]


COMPAGNIE DES FREINS ET SIGNAUX

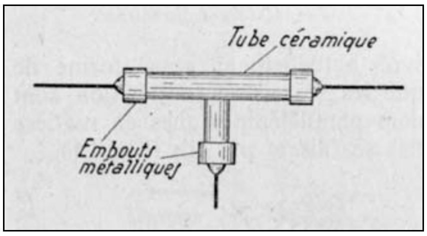
WESTINGHOUSE

16, RUE DE LA VILLE L'ÉVÊQUE · PARIS 8e

Letter head of CFS Westinghouse, 1953 (Author's collection)

In February 1954 the Westinghouse GAN-1 was the only French transistor cited in a table of transistors commercially available in France. [TSF 54 02] 1954 was also the year where René Sueur, who had long defended his preference for the point-contact transistor, appears to have realized that the future was in the junction transistor.

In 1954 Motte wrote the first French book devoted to the transistors. [MOT 54] CFS Westinghouse is not cited and the Transistron appears anonymously in a drawing that is similar to the GAN-1 and implying its obsolescence in the legend for the figure:



Drawing from [MOT 54] to illustrate the form of the "first transistor" (sic)

In 1955 the "Lexique Général des Transistors" was published and was the first French book containing the "characteristics of all transistors and schematics," by Motte. [MOT 55] It is surprising to see that whereas new French transistors appear neither GAN-1 nor even CFS Westinghouse are mentioned.

Would the Transistron be denied an epilogue? Not quite: in the 25th anniversary edition of *Toute la Radio* in 1959 there is a passing reference to the first production of transistors in Europe in a section devoted to the history of CFS Westinghouse:

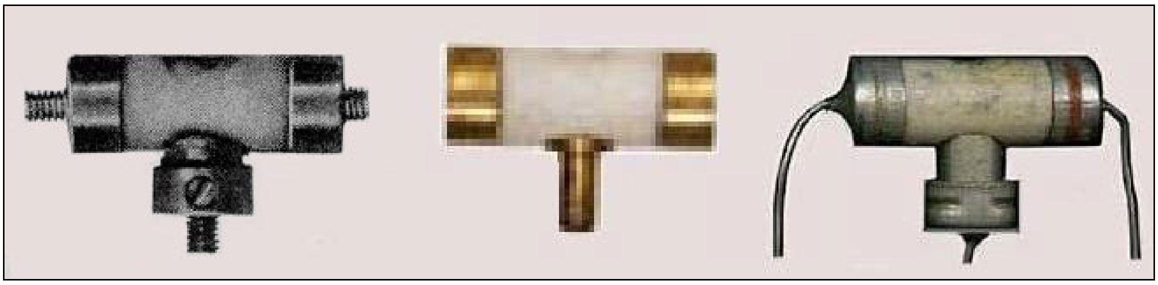
> *At Liberation in 1945, the occupation had placed France behind on certain technologies, particularly in the domain of germanium semiconductors suitable for radar.*
>
> *The French telecommunications administration gave Westinghouse the mission to fill this gap. Research and production of the first germanium rectifiers and transistors were successfully launched in France.*
>
> *Since then, Westinghouse was mainly confined to the development of germanium and silicon rectifiers, for industrial applications. [TLR 59 03]*

Excerpt translated from Toute la Radio Anniversary Edition, March1959

After its exceptional development of the Westectal diodes and Westcrel GAN-1 crystal triode, CFS Westinghouse moved its focus to power electronics and industrial rectifiers.

In four short years the Transistron evolved through three designs before becoming obsolete:

-	For its launch in1949 it is called the « Transistron Triode type P.T.T.601 » [LOE 49 11]
-	Then in 1950 [TLR 50 03] it is called « WESTCREL type N crystal triode »
-	And finally it is named the GAN-1 in 1953 [TLR 53 07]



Development of the Transistron 1949-53 (Photocomposition by Mark Burgess)
Left: Transistron P.T.T.601 of 1949, Middle: Westcrel Type N of 1950; Right: GAN-1 of 1953

7) CONCLUSION

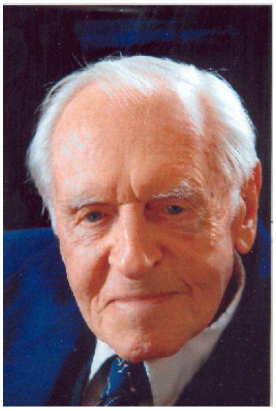
At the end of the Second World War, France was aware of its backward position in the field of semiconductor diodes for military applications (radar) and civilian applications. Two German scientists, Drs Mataré and Welker joined the independent French Company CFS Westinghouse and under a government contract, developed Westectal germanium diodes and then the Transistron. This was the first European point-contact transistor, developed independently and soon after Bell Laboratories. However, the transistor prior art was American as clearly established by patents.

The story of the parallel invention of the point-contact transistor in America and France should be better known, especially and paradoxically in France, where the historical reality of the Franco-German Transistron has been somewhat overlooked, even though careful reading of journals from the period and the technical literature makes it possible to trace it.

It is interesting to note that for both the US team at Bell Laboratories and the Franco-German Transistron team, the invention of the point-contact transistor came from experiments on duo-diodes. Bringing two polarized point-contacts into close proximity on a common germanium base creates interference between them: the current of one affects the other and a transistor is born. On both sides of the Atlantic the point-contact transistor was a direct outcome of research done on the UHF radar diodes and sufficient knowledge of the purification of germanium.

The Franco-German point-contact transistor, the Transistron, has emerged from oblivion through the efforts of H Mataré to raise awareness about his contribution to this remarkable invention. His article "The Lesser Known History of the Crystal Amplifier" was not accepted by the symposium reviewing committee of the IEEE celebrating the 50th anniversary of the transistor. [MAR 03] Thanks to the German doctoral thesis of Kai Christian Handel, [HAN 99] and especially through the work and energy of the Belgian Armand Van Dormael [DOR 04,DOR 08] and the American historian Michael Riordan [RIO 05] this story is back on center stage. In Germany, unlike France, this story has been told in the national press. [SPI 08]

Dr. Mataré is still active in 2011 and lives now in Germany. He has authored over 80 patents. His personal records and prototypes of the Transistron illustrated in this article are archived at the Deutsches Museum in Munich. in 2008 he received the Ehrenring Prize (German “Ring of Honor") which is considered the Nobel Prize of technology in well deserved honor of his work. [KOB 08]



Dr Herbert Mataré in 2008

For France, the history of the Transistron is the story of an unexploited technological advance. After developing the first European point-contact transistor France did not exploit its initial advantage and capitalize on the effort. France lagged behind the US and also Germany. France focused too long on the point-contact transistor and germanium technology, while the future was given to the junction transistor and silicon.

In the extremely difficult context of the post-war years the Franco-German Transistron was the first transistor mass produced in Europe, foreshadowing European research collaboration and also opening the way for the junction transistor in a Continent devastated by World War II. This has been noted by the American historian Michael Riordan [RIO 05] in his excellent article, evocatively titled "How Europe Missed the Transistor":

> "Only four years after World War II had ended in Europe, a shining technological phoenix had miraculously risen from the still-smoldering ashes of the devastation" (Michael Riordan)

After having co-discovered the point-contact transistor, France, like all other countries, turned to the more stable and more easily mass produced junction transistor. 1955 was the year of the junction transistor in France.

Christian ADAM

Colmar, France, February 2011

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http ://www.radiomuseum.org/forum/les_premiers_transistors_composants_en_france.html

[ADAM 09] *Christian ADAM Q4 2009*
Le Transistron, clone franco-allemand méconnu du transistor américain
Bulletin n°64 du CHCR (Club Histoire et Collection Radio) pages 6 - 10

[ADAM 10] *Christian ADAM January 31th 2010*
Histoire du transistor à pointes en France
Published on the Radiomuseum.org site:
http://www.radiomuseum.org/forum/histoire_du_transistor_a_pointes_en_france.html

A fuller version, Le Transistron de la Compagnie des Freins et Signaux WESTINGHOUSE et les autres transistors à pointes français may be downloaded from the CHCR site:
http://www.premiumorange.com/chcr/images/articles/Transitron.pdf

See also ***[FEB 10]*** *:*
Le transistron de la Compagnie des Freins et Signaux WESTINGHOUSE

[BELL 51] *Internal Memorandum 1951*
New Bell Labs Transistors
Courtesy Jack Ward

[BOT 94] *Antonio José J.BOTELHO 1994*
'The industrial policy that never was: French semiconductor policy, 1945-1966'
History and Technology,11:2,165 — 180

[BUR] *Mark BURGESS*
A History of French Transistors
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[CFSW 47] *Compagnie des Freins et Signaux WESTINGHOUSE May 23th 1947*
French Patent n° 22 307 for the UHF duo-diode
USA extension n° 2 552 052 filed April 21th, 1948
Inventor H. F. Mataré

[CFSW 48a] *Compagnie des Freins et Signaux WESTINGHOUSE August 13th 1948*
French Transistron patent FR1010427A
Inventors Drs Mataré et Welker
http://v3.espacenet.com/publicationDetails/biblio?CC=FR&NR=1010427&KC=&FT=E

[CFSW 48b] *Compagnie des Freins et Signaux WESTINGHOUSE 1948*
Data Sheet n°52 « Eléments redresseurs OXYMETAL Type 29 S 5 F (Westector W) pour hautes fréquences »
Author's collection

[CFSW 49] *Compagnie des Freins et Signaux WESTINGHOUSE January 1949*
Data Sheet n°78 « Caractéristiques et encombrement des WESTECTAL à cristal de Germanium »
Author's collection

[CFSW 50] *Compagnie des Freins et Signaux WESTINGHOUSE December 1950*
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