Modern radio pioneers: John Sargrove and Paul Eisler. The automatic radio factory and first printed circuits

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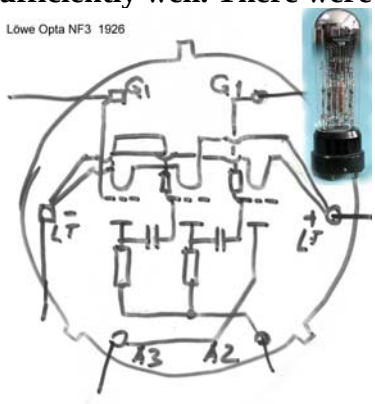
Picture 1. Sargrove’s automatically manufactured radio was an inexpensive people's radio

The Hungarian engineer John Sargrove was born in 1906 and died in England in 1974. He was one of the first builders of automatic factories. Sargrove was working for Tungsram’s radio tube factory in England. There he tried making components by spraying zinc and graphite in the grooves of Bakelite in 1936. He made out of zinc coils, conductors, capacitors, and plugs. Molten zinc was sprayed on a coarsened Bakelite plate. By spraying graphite into the grooves, he made resistors by a mass production method into the same Bakelite plate. Even today, spraying zinc on them makes connection surfaces of power capacitors.

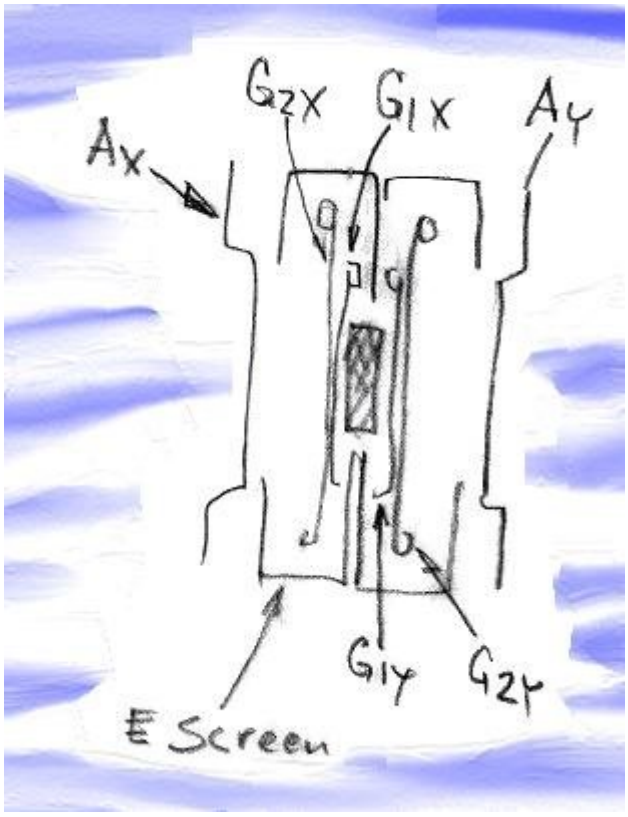
Picture 2. The basis of Sargove radio was a general tube, UA-55, witch fit every purpose sufficiently well. There were two tube functions in the same envelope.



Picture 3 Loewe Opta made first integrated circuit, capacitors, resistors and tubes used in radio, which had only on taxed tube.

Sargrove also developed a tube for general use. Its type was UA-55. Its characteristics were slightly lower than that of special radio tubes, but it suited Sargrove's ideas. Loewe Opta in Germany used a same kind of idea in 1926. There the idea was based on the taxation of German radios. The tube radios were taxed according to the number of tubes they contained. There were three tube functions inside one Loewe NF glass tube. There were also five diodes and two capacitors. I wonder if this was the first integrated circuit. At least the Germans think so.

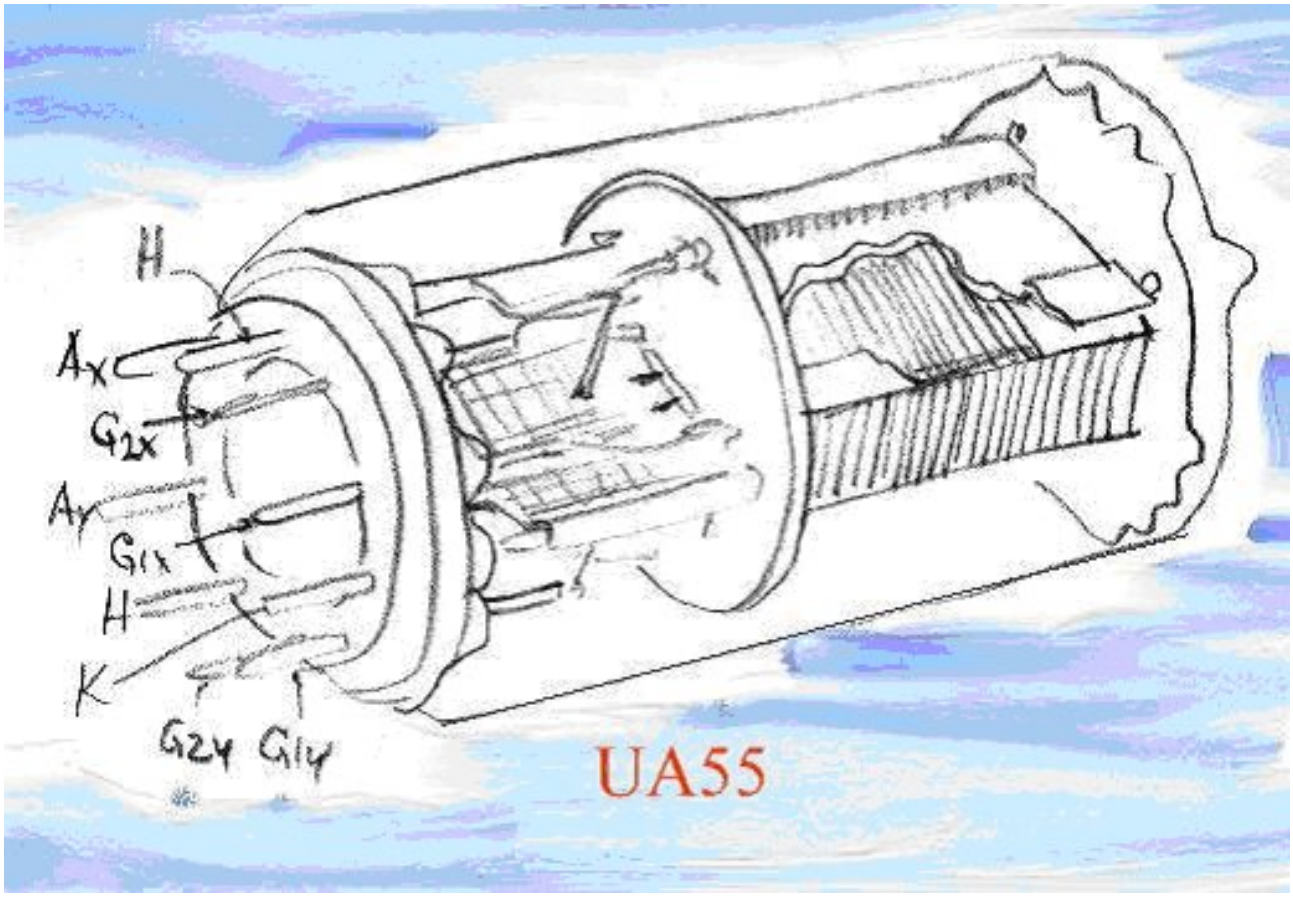
The heater of Sargrove's tube operated at 55 V and 100 mA. A four-tube radio suited well for 220 and 110 V mains voltages. The tubes used as a full wave rectifier for power supply, an oscillator/mixer. Two tubes were used in intermediate frequency amplifier and as an audio/detector. The small size of the tube limited the output power of last audio tube. Only one watt of audio power was got to a 2500-ohm load in the class A. Then the total loss of the tube was 3.5 W. The bias of the control grid was -5 V and the gain of the tube was -7mA/V. A common cathode worked well in oscillator and mixer circuits, but there were problems in combining audio and RF side into the same tube. A common cathode required special neutralizing circuits. A double tetrode type tube had a common heater and cathode. There was separate control grid G1, acceleration grid G2 and anode for both the tube circuits. The tube has 9 pins but the there were no 9-pin sockets available of that time. Sargrove made a decision to make socket for this tube a socket of its own. 1 mm thick pins had 36 degrees pitch except for anodes that were separated by 72 degrees.



Picture 4 Sargrove's UA-55 tube had a common heater (55 V 100 mA) and cathode. The control grid, the braking grid and anode were separate for each tube. The 9-pin base did not

fit mechanically the sockets manufactured at those days. Sargrove had to design a new base. It was basic to an automatic radio factory.

Because Sargrove had made connectors with the zinc spraying method, he decided to make this new tube base using the same technique. Making the tubes was mass production and the tube factories used automation technology available in those days. From this, it was not a big leap to start thinking of an automatic production line of tubes, its sockets, and components, an automatic radio factory. Making it work is other thing, but Sargrove succeed.



Picture 5 Sargrove's UA-55 tube's pins were in 36-degree angles, except for anodes that were 72 degrees separate.

In 1947 Sargrove got finished all the parts of the automatic radio factory in six years and founded the company Sargrove Electronics Ltd. The purpose of the factory was to remove human mistakes and to reduce the work force. The reduction of work force was not to the liked of many people and this brought negative publicity to the project.

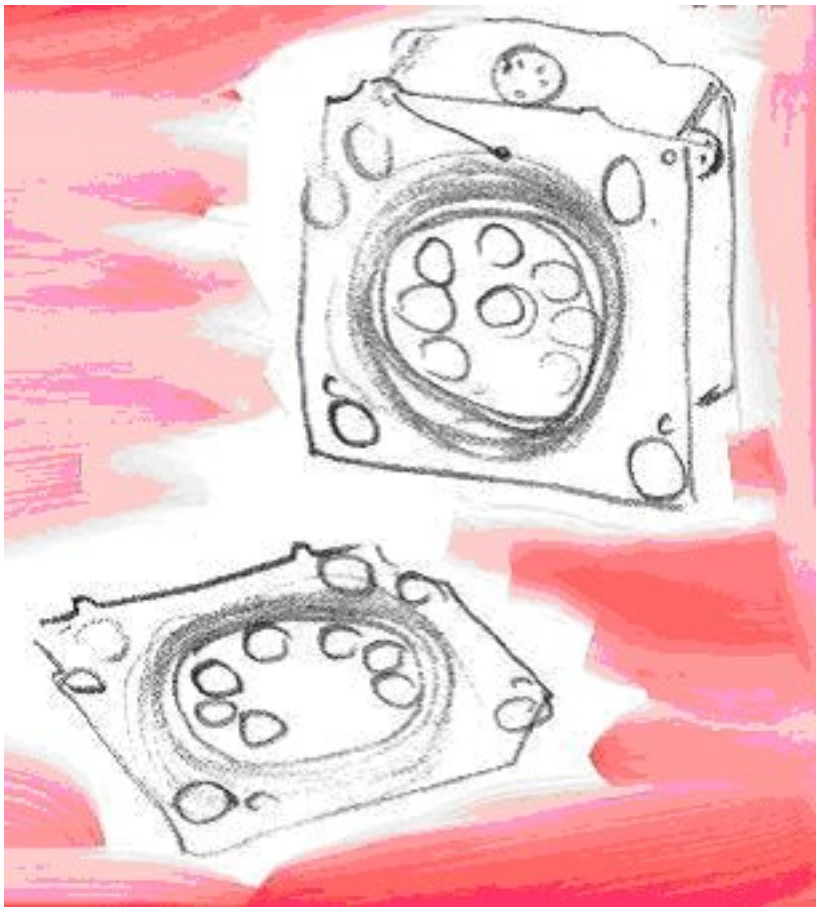
John Sargrove's greatest idea was an automatic Electronic Circuit Making Equipment (ECME). ECME made and automatically tested radios.

Picture 6 In Sargrove's automatic factory there two 26 meter machines, between which passed a conveyor.

Almost finished radios came out of the production line. In the picture, a worker is fitting four UA-55 tubes into the radios and after that they go to another line, where radios are tested automatically.

It consisted of two 23 meters long, 2 meters high and 0.6 meters wide machine, which were united by a conveyor. At the other end were the workers who filled the material storage spaces. From the other end, almost finished radios emerged. Four pieces of UA-55 tubes and electrolyte capacitors of power supply were installed manually. The other line made cases, which had a speaker, installed. By combining these two partial components a functioning radio was made up. Lastly, the radio went through automatic testing equipment where 50 check-ups were made.

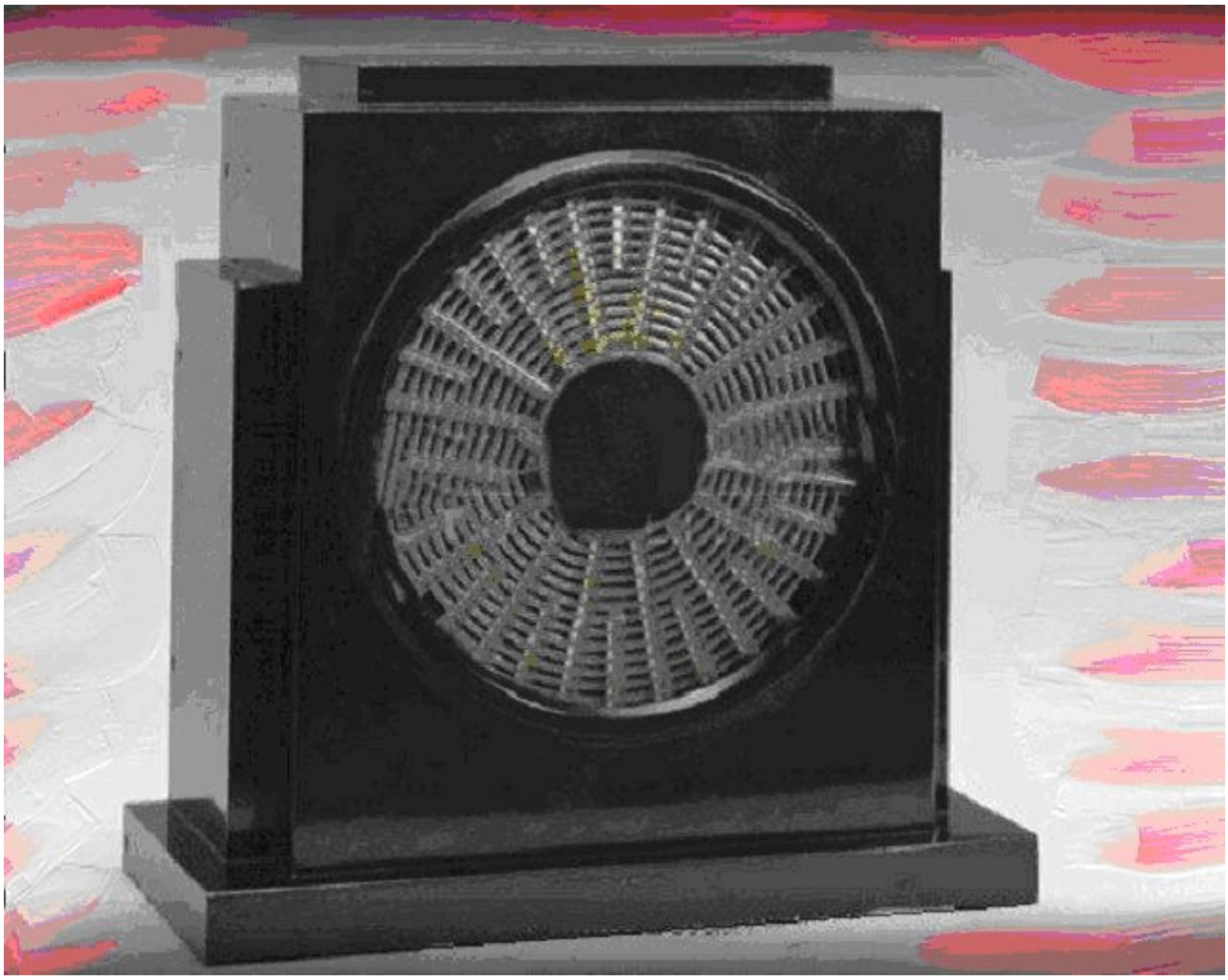
There were only 50 workers in the factory. Normally, a factory of the same size used 1500 workers.



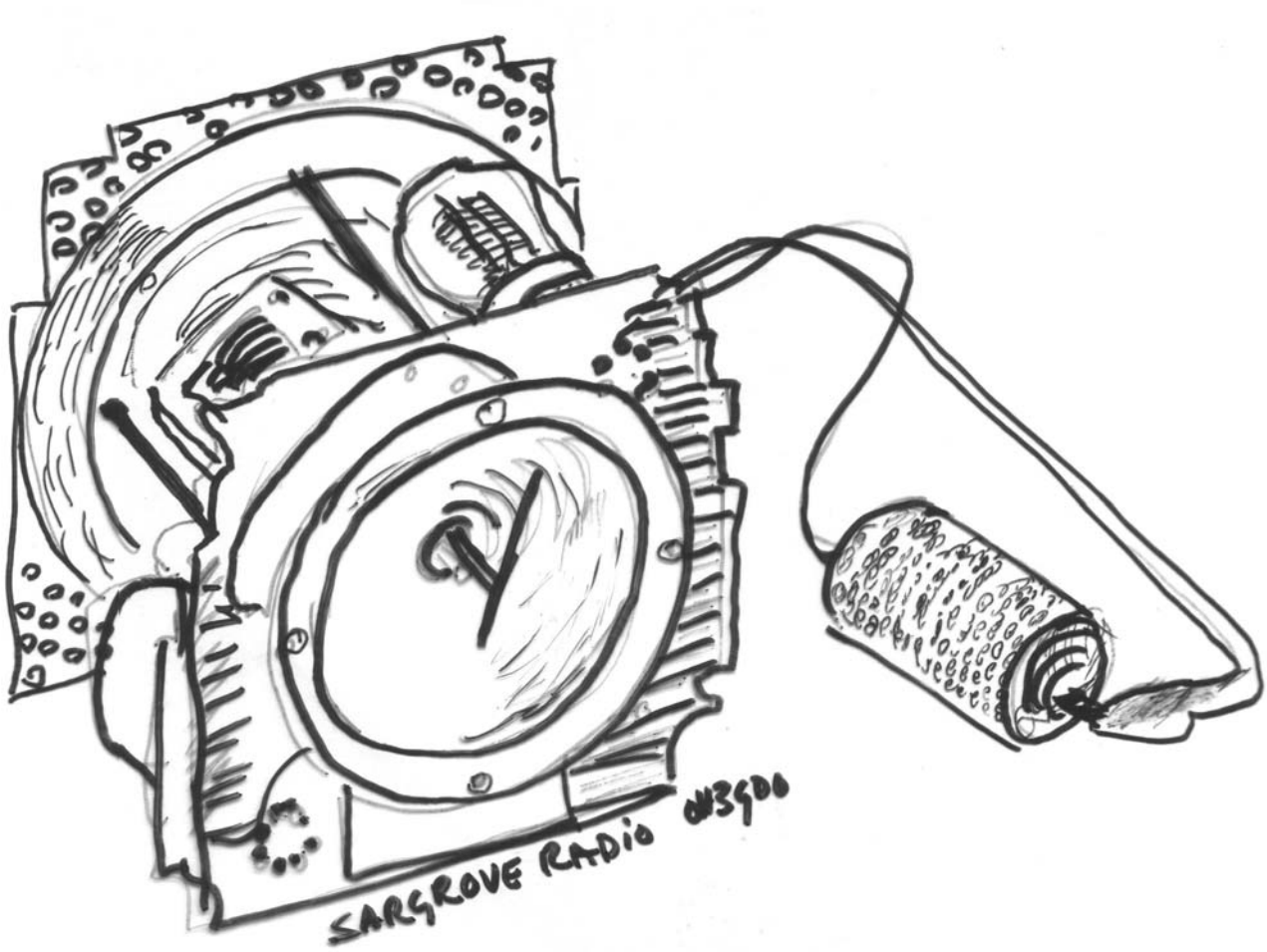
Picture 7 Sargrove's radio consisted of two Bakelite plates, between which the tubes were installed. The inductances were printed on the surface of Bakelite. The same way with resistors, potentiometers and capacitors

Bakelite made even the chassis of the radio. First the chassis was protected with a rubber plate mask. It protected the places that did not need grooves made. A sand blower formed the grooves of the first layer. Grooves consisted for instance of horizontally winding coils and straight grooves worked as conductors between different parts.

Picture 8. A big inductance is shown on surface of Bakelite. The resistors, wires, connectors, potentiometers and capacitors were made automatically, like a hybrid circuits today.



Picture 9. The outlook model of Sargrove's radio. This model has no electronics.



Picture 10. This picture is probably closest to a finished Sargrove radio. The tubes are between the circuit board.

In front a speaker, behind a station selector. The radio probably worked only on the medium waves. The transformer in the middle is the impedance transformer for speaker. The anode loads of the tubes were about 2500 ohms. The speakers had then as today also low ohm impedance, about 4-32 ohms. The metal cylinder in the right is probably the series resistor during testing for 220 V. The picture cannot be of a finished radio, since the tubes have 7-pin sockets and they are bulged tube models like AZ-1. UA-55 was a straight tube with 9-pins. UA-55 also did not need a high power series resistor like in the pictures. In the picture there is moreover an aluminium chassis, which has a punched holes. Later chassis were integrated to bakelite case.

Sargrove's achievement

Taking into account that Sargrove had no models to follow, an automatic radio factory is a tremendous achievement. The world needs models. Everything is easy when somebody has shown it first. Many may remember a story of the egg of Kolumbus.
The integration of Sargrove's components would have been a great invention itself. Sargrove however wanted everything, also the construction of the automatic factory, automatic testing equipment and global marketing. It is difficult for one person to control all sectors. Nikola Tesla, who is among the greatest men in electric technology, also tried to control global information transmission with his Wardenclyffe station. Sargrove and Tesla got to experience that you have to take into account economical factors. Both of them run out of money before their inventions started to flourish. Sargrove made one million radios in firs year. He got a big order from India, which belongs to British Commonwealth. He started to build the order, but the India got its independence and the order was cancelled. Sargrove went to bankruptcy.
There are no pictures available about John Sargrove. There are no pictures available about Sargrove’s radio. [5]

The first circuit boards

The first mentions in patents were about printed conductors in 1903 (reference 2). In 1925, the American Charles Ducas applied for a patent to make wires directly on an insulation plate by printing conducting ink through a stencil. This gave the method the name printed circuit.
The first one to build printed circuits was doctor **Paul Eisler.** He was an Austrian, but escaped the Nazis to England in 1936. He constructed radios, in which printed circuits were used in Hempstead in his rental apartment. He had no work permit and on top of that he was from an enemy country. In 1941, he got work in the movie theatre Odeon and there he invented detachable protective covers for the seats of the theatre.

Picture 11 The inventor of the circuit plate doctor Paul Eisler built radios with a circuit plate at year 1941

After different stages in 1941 he got a patent for printed circuits. A lithographical company stole the rights for it at first meeting with Eisler. Eisler lost his rights through a lawyer's trick (text in small print). In 1943, he got a new global patent for printed circuits, in which copper plating is used in a resin strengthened by fiberglass. It may be used instead of conductors in motors, plugs and antennae. Eisler also invented heated wallpaper. The walls were warmed using printed circuit technology. It might have become a success, but at the same time gas was found in the Northern Sea and in England electric heating had to make way for gas. Printed circuits were put into use in a more widely from the beginning of the year 1948 in aeroplane meters. When transistors

circuits started 1956, printed circuit board technology was used in all factory-built radios.
Later Eisler invented a car back window heater functioning with the help of circuit plate technology and also a pizza heater for car for the time spent in transportation.

Picture 12 Two sided through coppered circuit plate with LCD and processor

The American company Hazeltyne got a patent for through plated holes in multiplayer boards in 1961.

Picture 13. Tugsram radio poster by unknown artist probably 1938 era

Links :

1 http://www.sciencemuseum.org.
2. http://www.trianglecircuits.com/pcb-history.html

3 Wireless World 1947, April sivu 484
4 1952 Rolf Strehl ("Die Roboter sind unter uns")
5. http://www.madehow.com/Volume-2/Printed-Circuit-Board.html
6. Loewe-Opta http://www.radiomuseum-bocket.de/

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[5] Final words.

After this writing appeared in Finnish Paper “Radioamatööri”, 2007. I got information that one Sargrove’s radio exists in Powerhouse Museum at Australia.
http://www.powerhousemuseum.com/collection/database/?irn=206893&search=sargrove&images=&c=&s=
I got this information from:

Campbell Bickerstaff, Assistant Curator, information & communication technology, Curatorial

campbell@phm.gov.au, (02) 9217 0290

Picture 14. A picture in web page of Powerhouse Museum -

I am waiting to confirmation to this. Maybe a photo or someday visit to Australia will confirm this.

My fiend Leigh Turner, VK5KLT, from Adelaide travels between Australia and Finland quite often. Maybe he will someday visit Melbourne.

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