Mystery of theBroom Antenna

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Well known in Russia broom antenna has some mysterious property. What is the property- the puzzle try to solve Vladimir Polaykov.

1. History of the Broom Antenna (BA)

Broom Antenna has been well known in the USSR from old times. I have a Russian amateurs magazine from 1935 **[1]** with description of the antenna. “The antenna is made from a bunch of lengths of wires. There are used wires by 23 centimeters long. Narrow end of the bunch is inserted to an porcelain insulator. Wires in the bunch had angle in 15 degree from the center. A copper wire 15 meters long is going from the bunch to a receiver.” I cannot do scan for the figure from the magazine because its bad condition. However I pictured it possible to close to the original figure. **Figure 1** shows the design of the broom antenna. The antenna was conveniently for the times because it needs only one mast for its installation.

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Plate 8.4 Twelfth-century mural of the goddess Frigga riding a distaff, in the cathedral at Schleswig, Schleswig-Holstein, Germany. Nigel Pennick.

A witch usually used a Broom like a modern Jet

Sometimes the antenna was installed at a chimney, so no any mast was required. Up to our times the antenna is used for the radio reception (**References [2, 3]**).

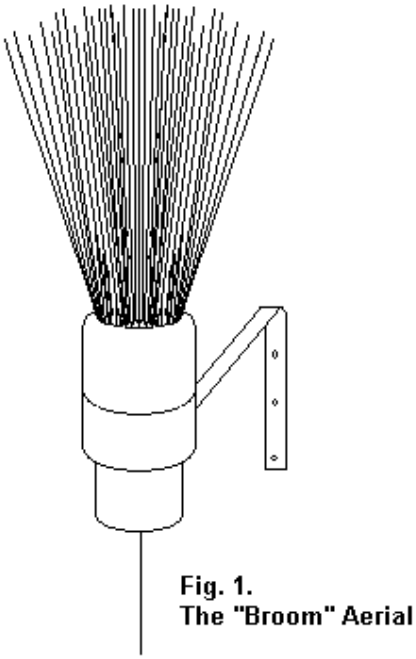


Figure 1 Design of the broom antenna

(***Note by I. G.:*** I had a book published at 1922 in Moscow where BA was described. However, at the book the antenna had a Reference back to 1916 year. It is a pity that I cannot take with me the old book in Canada. It is need to have a permission for any book older then 50 years to take the book abroad of Russia. It is not easy to obtain such permission, so lots old books were lived by me at Russia… **Figure 01** shows a broom antenna from a book published at 1938 (original scan from book by A. P. Gorshkov "Handbook of Radio Amateur: Questions and Answers", published in 1938 in Moscow)

See also at horizontal antenna, competitor for the BA (**Figure 02**, original scan from the **[01].** The horizontal antenna was mostly popular at the 30s.)

At the magazine was written that an US company 'Central Equipment Ltd' produced the Broom Antenna. Wire going from the broom to a receiver was thoroughly insulated from walls with special insulators. Inside room the wire go through a special ebonite tube. It is pay attention the very careful isolation of the antenna wire from the nearest objects. A special grounding kit was included to the antenna.

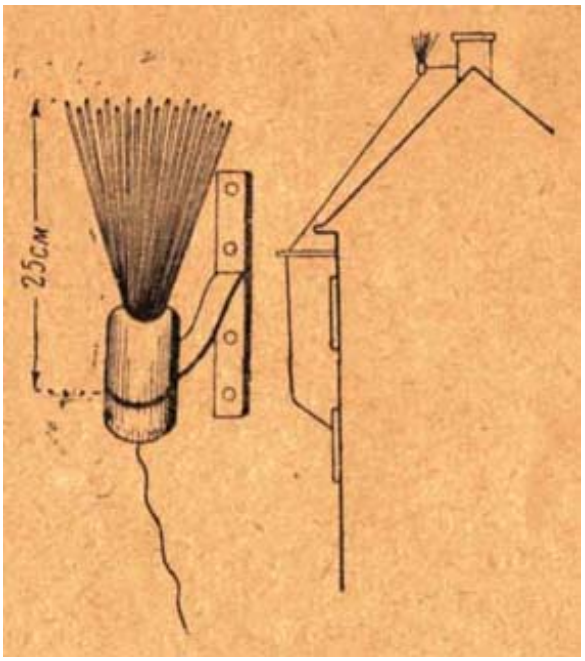


Figure 01 Broom antenna from a book published at 1938

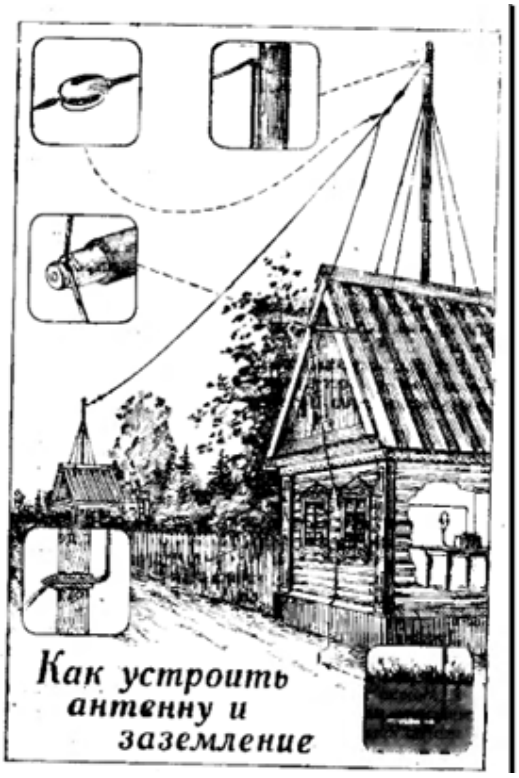


Figure 02 Horizontal Antenna

Figure 03 (***drawn by I.G. by Reference 1***) shows the grounding installed in the soil. It was a copper tube with holes filled by so name "silitit" (Russian hams at such grounding used instead the "silitit" a charcoal). Bunch of copper wires went down the tube. So, the grounding looks like a Broom Antenna reversed by the wires bunch to the ground. At advertise of the company was wrote: "…. Above the advantages of easy in the installation the antenna has advantages in the reception". Last phrase was puzzled me, what are the advantages?
As usual BA antenna is considered as wire antennas with a capacitive load. Capacitive load made like a metal sheet was used by Hertz and Popov **[02]**, capacitive loads made like several wires at the antenna end was used by Marconi **[02]**, capacitive loads made like wire's toroid was used by Tesla **[02]**. However, no one used a capacitive load made like a broom because it is not optimal implementation of this one.

Circle (having dimension like a broom antenna) with several radial wires will have the same capacity like the broom antenna. **Figure 2** shows a broom converted to an optimal capacitive load. At some description of the BA I found recommendation to use a strictly numbers of wires (19, 37 or 61 pieces) with length 50- 100 centimeters and use angle between center line and wires from 45 to 90 degree. Of course, it is nonsense. In theory 7 wires are enough for the antenna. BA made from 19- 37- 61 wires will have only a slightly more capacity compare to antenna made from 7 wires….

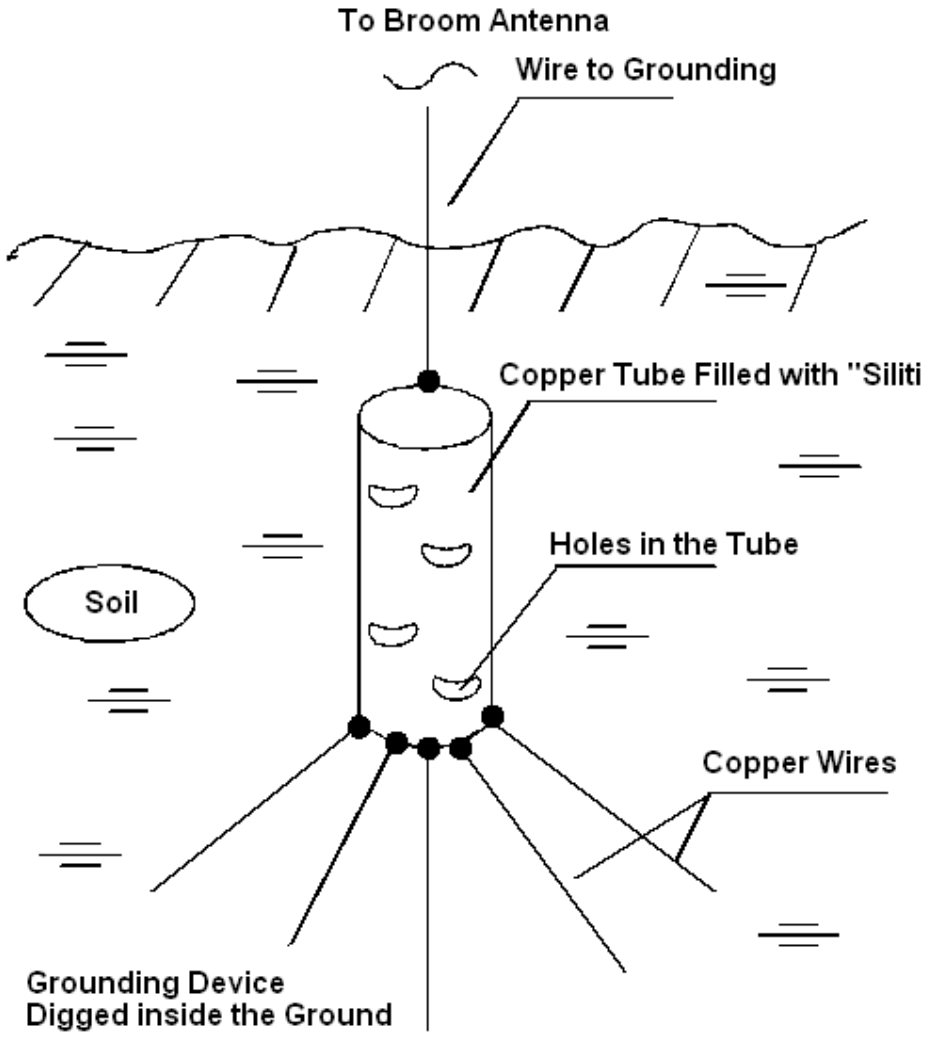


Figure 03 Grounding for Broom Antenna Installed in the Soil.

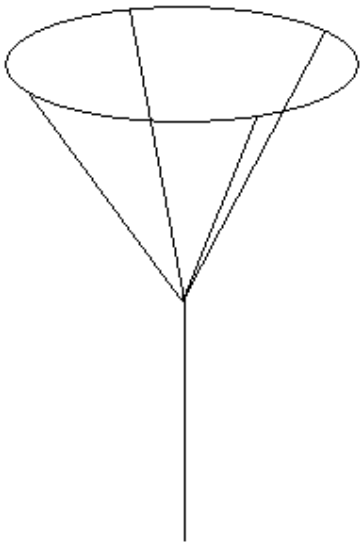


Fig. 2.
Better capacitive load

Figure 2 Broom converted to an optimal capacitive load

So in the theory there is no any advantage of the broom antenna before another antenna with a capacitive load.

However, a small metal 'broom' was used for discharging of some parts of electrostatic machines from 19 century. Recently the metal 'broom' are widely used at the end of antenna mast (that installed on the ground or on a ship), at the end of jet wings for leaking the static from the jet to the air. The 'broom' discharger looks like a Broom Antenna…

So, what is can discharge the broom from the antenna?

2. Atmospheric electricity

What are we know about an atmospheric electricity? Near the ground surface there is gradient of potential, i.e. strength of the electrostatic field is near 130 Volts/meter. At height of the human head the strength of the electrostatic field is near 200 Volts/meter. However we do not mention the potential because the air is very good insulator and current going through our body is too small. The more up the more potential will be. It is come due the follow effect. Upper layers of the Earth atmosphere are ionized (so called ionosphere) by the Sun rays. Ionosphere layer has some conductivity and charged positively (due some process) compare to the Ground surface. So, mankind lives between two plates of huge capacitor- one plate is the Ground another plate is the Ionosphere.

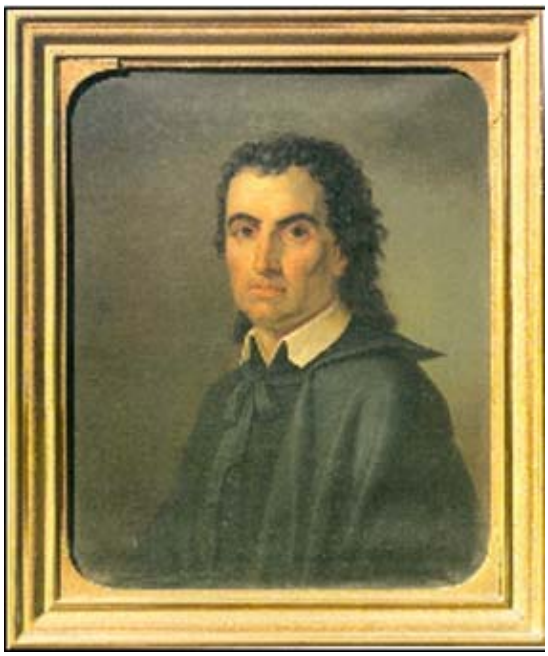
However it is a small ionic current flow down to the Ground. It is very- very small current. The current density being measured by a high sensitivity device is several pico- Amperes per square meter. Scientists do not clear explain the phenomenon. One of hypothesis says that the current exists due lightning and thunderstorm **[4]**. Really, before a thunderstorm the current is increased dramatically and sometimes we could register the effect visually. It is the corona discharge – bright glowing at the end of high metal mast, sometimes the corona charge is going from trees, wooden or metal cross at the top of churches. Corona discharge is especially bright in the mountains and in the sea (where the air is especially clear). Such Corona Discharge had been well known from the very old times, it was called *Saint Elmo's fire.*

Saint Elmo's fire

Atmospheric electricity had been studied from 17- century **[5]**. Lots great scientists (in the US Benjamin Franklin **[03]** the inventor of the lightning rod, in Italy Giovanni Beccaria **[04]**, in Russia- Mihail Lomonosov and Georg Rihman **[05]**). Franklin studied the effect with help of a metal wire lifted with help of a kite in the sky.

Benjamin Franklin

January 17, 1706
April 17, 1790



Giovanni Battista Beccaria
1716 - 1781

Another portrait of Benjamin Franklin

Lomonosov and Rihman studied the atmospheric electricity with help of a high raised metal rod, Rihman was killed during the experiments by a lighting. Giovanni Beccaria such metal road firstly connected to the earth , then connected to electroscope and then observed the reaction of the device. So, he could measure the potential of the road compare to ground. Beccaria called the metal road and electroscope “meter of the good weather.”

I tried to repeat Beccaria’s experiment. To my new installed 30- meter length antenna I connected an electroscope. While several minutes potential at the electroscope was raised to 1,500 Volts, then something clicked on my antenna (I believe some insulator sparked) and the electroscope was discharged. It happened periodically.

Electroscope used by Franklin and Beccaria

However, through several weeks I could not catch static at the electroscope. It is obvious antenna insulators catch dirty from the Moscow air and could not keep high static voltage across itself.

Mihail Lomonosov (1711—1765)

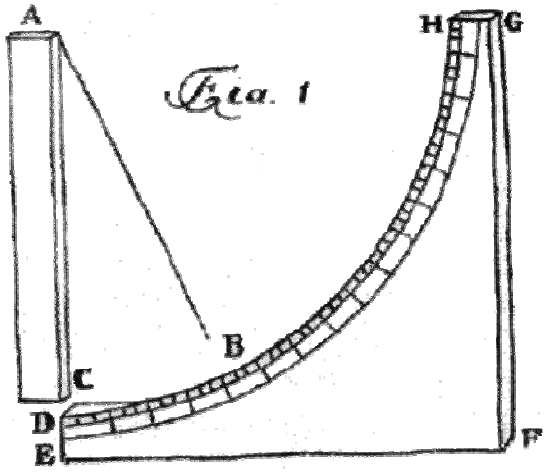
3. Current from the Air

Broom Antenna connected to antenna terminal of old radio as usual has ground potential because almost any old radio has coupling inductor where one end is connected to antenna and other end is connected to the ground. BA is placed near 10-15 meters above the ground where the air has potential compare the ground near + 2,000 Volts. So, from wires of the broom a small ions current is flow. The more wires in the broom, the more current go in to antenna wire. The more space occupancy wires of the antenna the more current go in to the antenna. The more sharpener are ends of wire of the broom, the more current in the antenna.

So, the current in the antenna direct depend from:

1. Numbers of the wire in the broom;
2. Angle between center line and wires;
3. Sharpener of the ends of the wire.

Georg Rihman 1711- 1753



Rihman's Electroscope

A- Wooden Strip
B- Flax Tread
C- Scale

Lots of the all description of the Broom Antenna pointed that the efficiency of the antenna depends from the factors, factors that increase the atmospheric current in the antenna. But how increasing of the current can influence to the reception?

I may suggest the follow hypothesis. Ion current flowing from the broom wires looks like short conductive path. Incoming radio signal may modulate the conductive path. So, atmospheric current going into antenna wire may be modulated by nearby radio signals. Antenna circuit is tuned to desired incoming radio signals, so only wanted radio signals would have maxima strength of the current…

Another suggestion. Ion current flowing from the broom wires may create a column of ions above the antenna. The column may work like an additional antenna connected to the broom, so, it looks like our broom antenna physically making longer by the column of ions.

I have read in one old book interesting note. Reception of DX stations coming better at winter windless evening when in the home began light the oven. When I read it I though it is nonsense. How an oven can improve radio reception? But for now I understood that it is not nonsense. Smoke from a chimney goes straight in the sky at windless weather. However the smoke column is a stream of easy-ionized air, so, the column has a little conductivity. Of course, such smoke antenna may improve performance of existing antenna or by re- radiation or adding its height to the existing antenna.

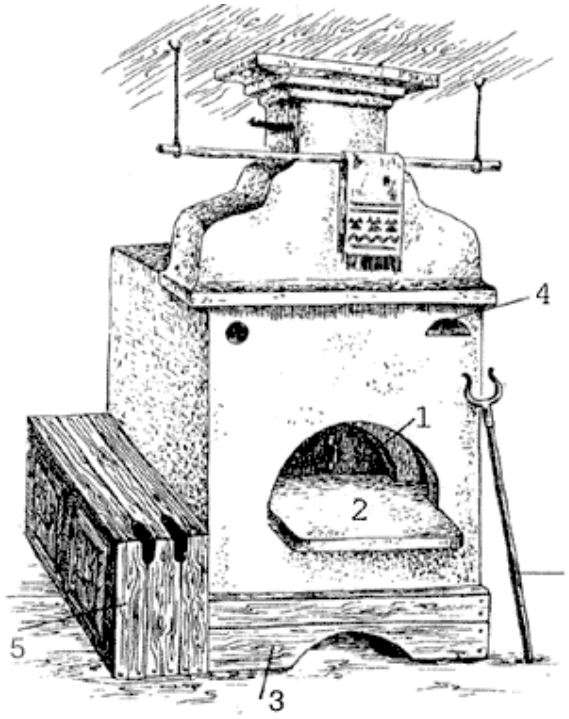
BTW from I.G.: It is really that a Russian Oven may be treated (with some limitations) like an ion generator…

Note by I.G.: At first it was strange to me. Why atmospheric current that flows in the antenna wire can improve the antenna performance? Another puzzle for me: in Russia Broom Antenna has another name – low noise antenna. Lots Russian amateurs handbooks described the antenna like low noise. For example, **[06]** described the antenna like low noise antenna for reception. I had used the antenna in 70s, I could speak that is really low noise antenna that gave good reception. However next chapters of the articles are cleared for me the puzzle.

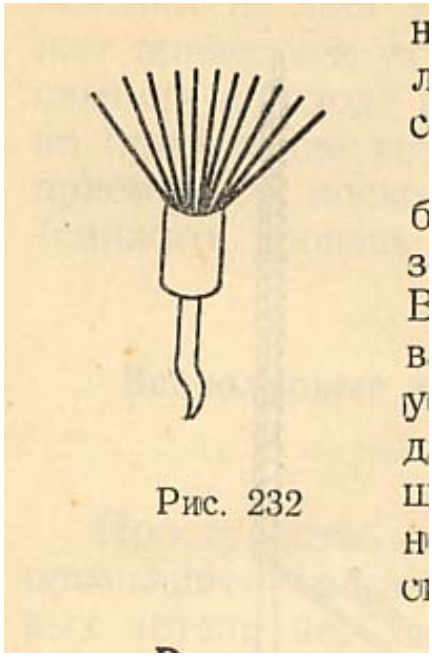
4. Parameters of Silent and Corona discharge

Lets examine volt/ current parameters of the broom antenna, i.e. how depends discharging current from potential between the air and antennas ends. If we will increase potential between the air and wires of the Broom Antenna the current that flow in the antenna also will increase. It is so called Silent Discharge that going because always there are some quantity of “free” ions in the air. **Figure 3** shows Antenna Current Vs Potential between antenna wires and the air.

Mystery of the Broom Antenna



Russian Oven- an Ion Generator?



Low Noise Broom Antenna from [06]

The further increasing of the potential between the air and broom wires result to dramatically increasing free ions near the wire the ions can do further ionization of the air near the broom wires and current in the antenna wire increase significant.

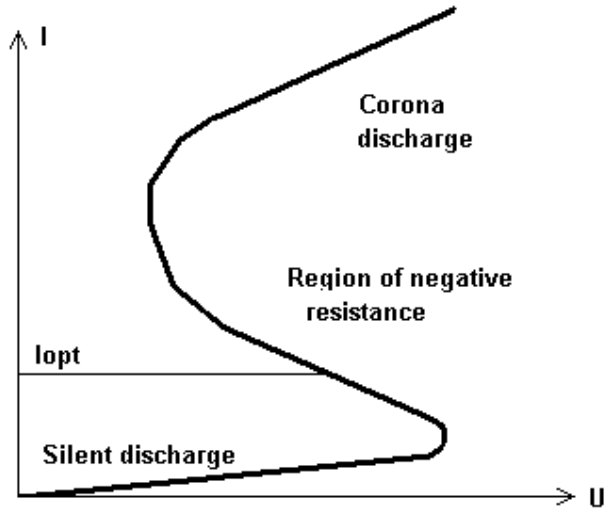


Fig. 3

Figure 3 Antenna Current Vs Potential between antenna wires and the air

Note I. G.: The process about appearance the corona discharge is described above with some simplification. If you print in GOOGLE "corona discharge" and then related phrase, you find hundreds pages containing lots equation… But I leave it to real fun of ***the corona discharge***.

It is may appear wonderful, but at some conditions it is very possible to turn the broom antenna into field having the "negative resistance." Proper height above the ground or proper conditions of the atmosphere may turn the antenna to field of the "negative resistance." In the **Figure 3** it is point ***Iopt***. To keep the antenna in the field of so called "negative resistance" it is need to stabilize current into antenna wire. It is possible to do feeding the antenna through "source of current." However, the atmosphere is an ideal "source of current." So being turn to the field of the "negative resistance" antenna may stay at the conditions quite enough long time…

5. Antenna Amplifier

Part of curve where potential drop but the current is risen is very interesting part of the curve. The part of the curve has so called "negative resistance." Electronic device that has curve with such "negative resistance" may do amplification (of course at some condition). The devices are tunnel diode, neon bulb, thyratron, thyristor. Tunnel diode is used for amplification and generation at VHF- UHF bands. Neon bulb, thyratron, thyristor is used for generation up to hundreds kHz.

Figure 4 shows the simplified schematic of Antenna Amplifier. In to antenna circuit is turn on the Broom Antenna. Current in the antenna circuit at resonance increases in Q times, where Q is Q-factor of the circuit.

Mystery of the Broom Antenna

Q-factor can be found as reactance of the circuit divided to resistance of losses. When the BA has negative resistance, the resistance compensates the resistance of losses in the antenna. Q-factor of the circuit is increased and RF voltage across the antenna circuit is risen. So, we have increasing in the receiving signals due feeding the antenna by atmospheric electricity.

Certainly, there are lots interesting questions about work of the Broom Antenna. What amplification the antenna may provide? What is the power the antenna gives?

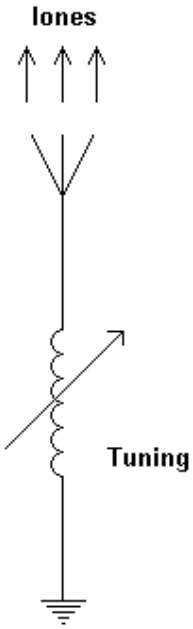


Figure 4 Antenna Amplifier

What is the lower and upper frequencies range of the Broom Antenna?

Be truth, I do not know answer on the questions. The Broom Antenna required more research. I will be grateful for any additional information from those who made such researchers.

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