# T H E  A R C  R A D I O  T R A N S M I T T E R S

Louis R. Mateo, WB2MVK
S.O.W.P. Member 878-PA

"TO OPERATE"

" 1.-Fill the alcohol cup and see that it feeds properly."

" 2.-Fill the water tank 3/4 full with fresh water."

" 3.-See that the valves of the water tank are open and that "
" the flow indicator shows a circulation of water when the "
" pump is started."

" 4.-See that all moving parts are properly lubricated."

Are these the instructions for the operation of some kind of "hot-rod"..?..perhaps for an outboard motor..?.. or maybe for a drilling rig on a Texas tower..?..

To many, the guessing game could be extended "ad infinitum"; but to few "Old Timers" this will bring back some nostalgic reminiscences, since the above instructions were part of the operation manual of a 2 KW Arc Radio Transmitter, made by the Federal Telegraph Co. of Palo Alto, California on/or about 1919; which were used on board Navy, Merchant ships and coast stations.

Let.s take a closer look at this piece of engineering ingenuity and we shall realize that the men who designed and put it together used a lot of "elbow grease" and mechanical skill in order to accomplish what now-a-days can be done with a few radio tubes or a bunch of semiconductors.

The basic function of the set, like others of that early vintage, (when Spark transmitters were still in a top position and tube sets were worming they way in)was to obtain undamped R.F. oscillations by means of an electric arc.

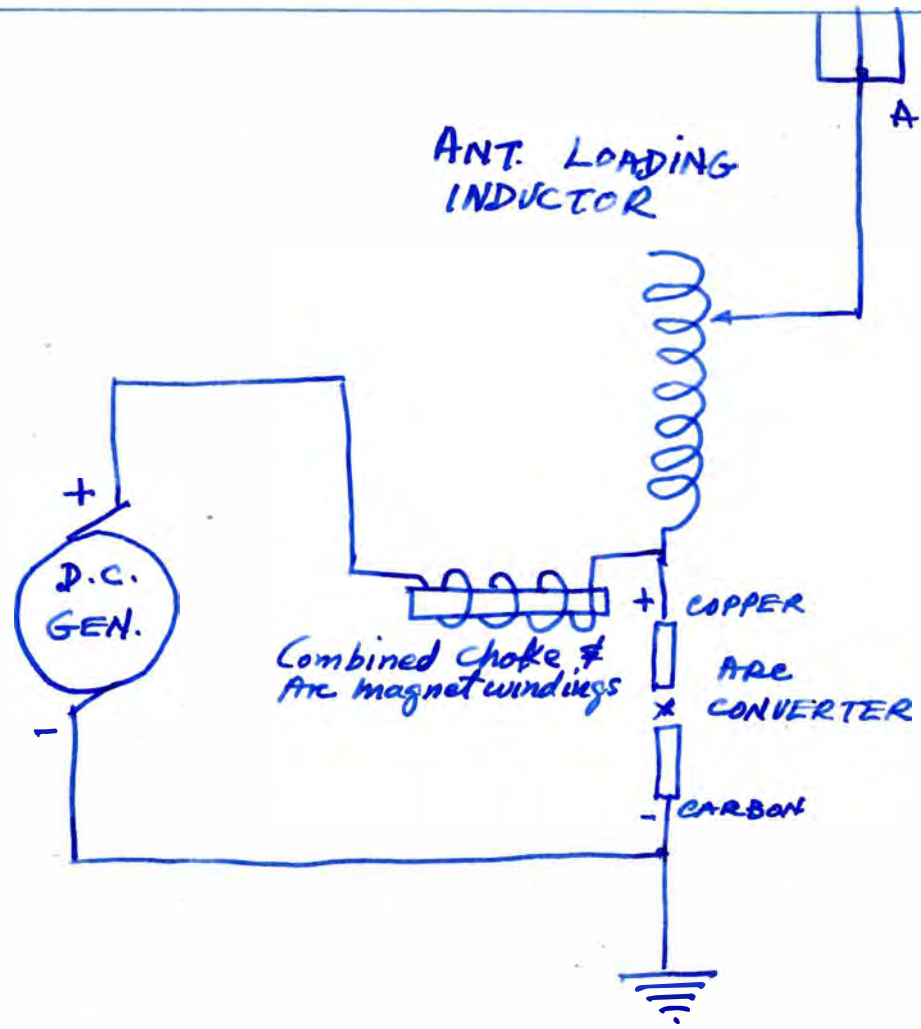



FIG I.- FEDERAL ARC TRANSMITTER. MAIN CIRCUIT. Keying circuit omitted.

The arc was enclosed in a chamber with an"atmosphere containing hydrogen"(more about that later) and a pair of electrodes were placed between the poles of a powerful electromagnet which produced a strong field which tended to blow the arc out. The negative electrode was made up of carbon or graphite, while the positive was made of copper and was watercooled. A water cooling system consisting of a water tank of about 15 gallons capacity, a rotary pump and electric motor; valves, hoses, couplings, etc. was included which each set. When in operation a flow indicator (a glass marble inside an small chamber) permitted to check up the water flow, either by ear (marble rattling) or visually by looking throughout the glass cover, and watching the "ball bounce".

The transmitter consisted of the following main units:

1.-A source of D.C. of suitable voltage. 2.-An arc converter. 3.-Antenna loading coil. 4.-Antenna and ground systems. 5.-Signalling device, and 6.-Auxiliary and control apparatus.

The essential features of such a transmitter and its main circuits are outlined in FIGURE 1. The arc converted the D.C. supplied by the generator into R.F. energy with undamped current in the antenna circuit, which included the antenna, the loading coil, the arc electrodes and the ground. The choke prevented the flow of R.F. from the arc back in to the D.C. generator and served to sustain and steady the arc.

The operating wavelenght (the word frequency was not much use in those days) depended upon the inductance and the capacity of the antenna circuit. Since the capacity was furnished by the antenna itself and was fixed; the inductance of the coil was varied by connecting the antenna at different points of the coil and securing the lead on its resonance point to a screw by a wing nut. Simple, but effective.

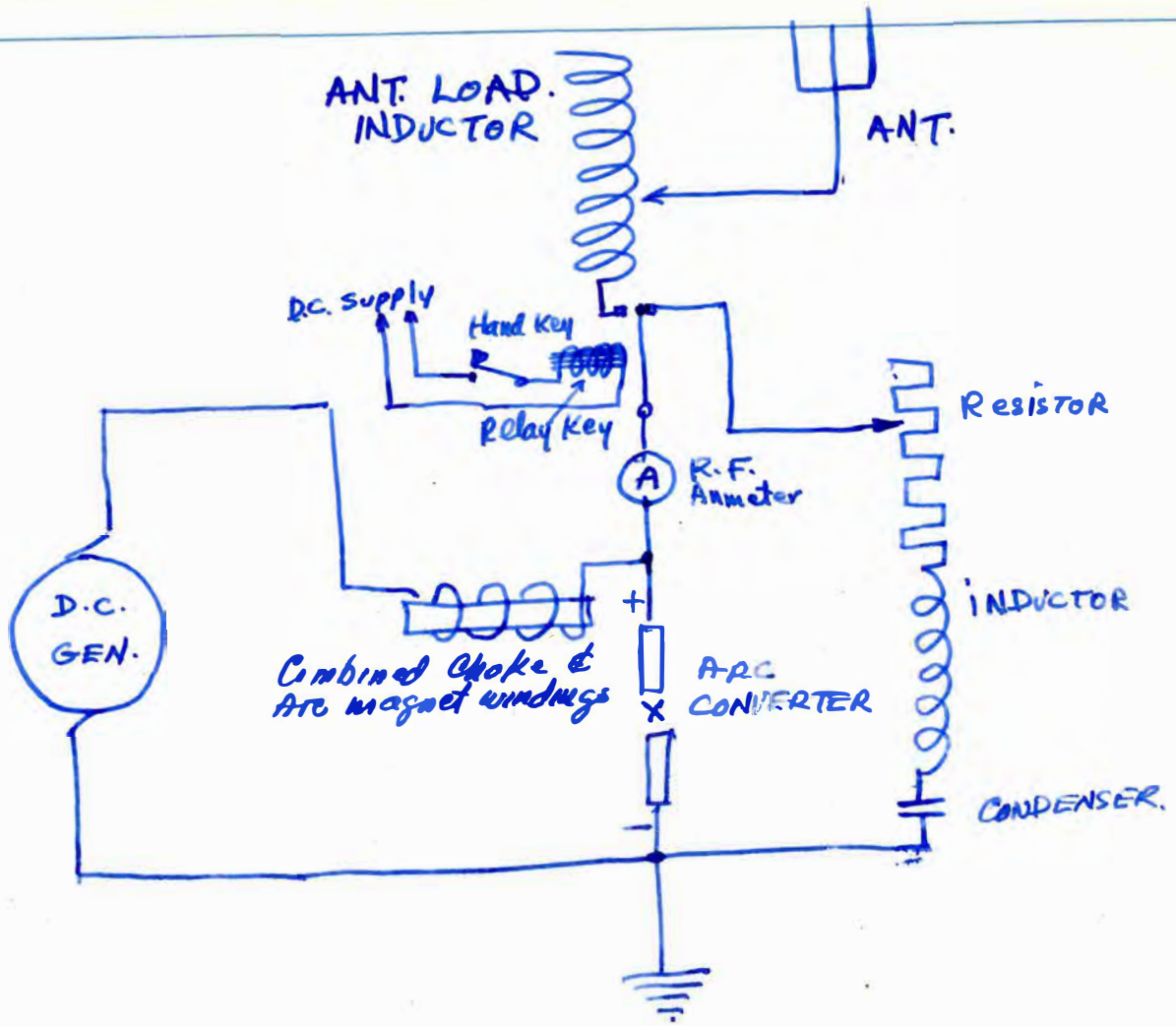



FIG II - FEDERAL ARC Radio TRANSMITTER.
Back shunt Method.

The wavelenghts normally in use on the merchant ships were 300, 450, 600, 750, 1.000, 1.400, 1.800 and 2.300 Meters. ( 600 Meters 500 Khz) is still used internationally for ship calling and distress traffic.)

A rotary converter boosted up the 120V D.C. ship/s mains from 200 to 400V. D.C. and the arc converted changed it to a high A.C. frequency of about 60,000 c.p.s. (60 Khz).

All parts of the arc converter were stationary, with the exception of the carbon electrode, which was rotated slowly by a shaft connected to a gear on the water pump shaft coupling, so that it could burn evenly. It was mounted in such a way so it could be screwed in and out, in order to strike the initial flame and adjust the arc inside the chamber. In actual operation the lenght of the arc flame was adjusted to secure a maximum output current indication and that was the only "tuning" required; although, now and them, small readjustments were needed. The carbon did not burn away as it does in ordinary arc lamps, usually it built up slowly, depending of the chemical composition of the gas in the chamber. And where did the chamber got the hydrogen atmosphere from? By the decomposition of the alcohol which was feed in, drop by drop and vaporized by the intense heat of the arc. Sometimes kerosene was used, it was claimed to be better in shorter wavelenghts- but a lot of soot accumulated in the chamber. Illuminating gas could be used when available, mostly at coast stations.

Keying.

With the arc in operation a continous flow of undamped current (CW) was noticiable in the antenna ammeter, and radiated as a continous carrier. Some means had to be deviced in order to key the transmitter and set out the "dot" and "dashes" of the Morse Code. The "muscle and brains department" solved the problem by three different methods and later by

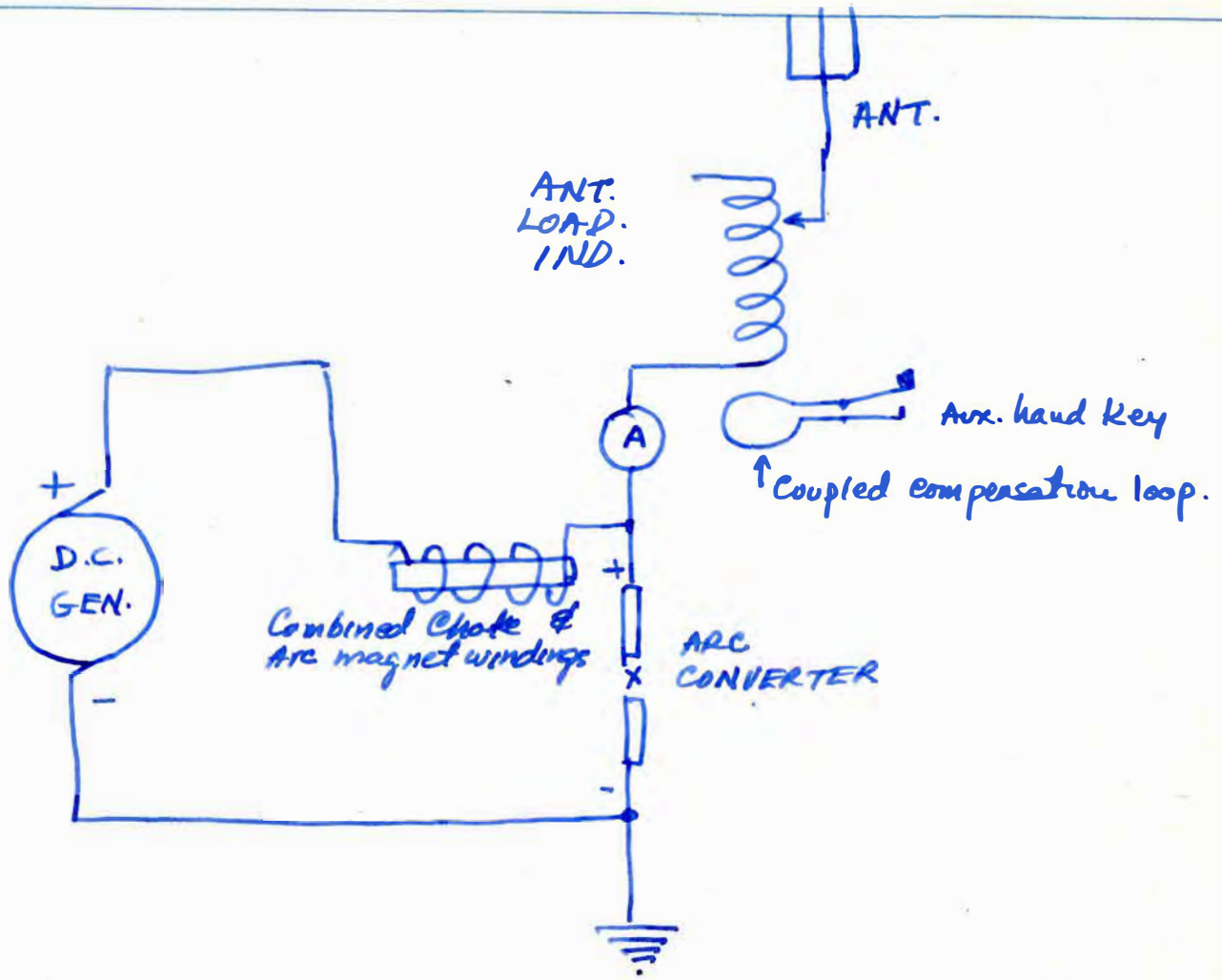



Fig III -- Federal ARC RADIO TRANSMITTER
Coupled Compensation Method.

another which eliminated two of the first three. They were;

1.- Back shunt method. 2.- Coupled compensation system. 3.- Chopper. Finally, 4.- Ignition method.

Both Navy and Merchant Ship equipments were equipped with the back shunt as principal means of keying. The couple conpensation system was supplied as an "extra". In both cases a chopper was used when the transmission was intended for receivers using simple detectors.

Back Shunt Method. FIGURE II.

Consisted of the following essential untis; back shunt circuit, back shunt relay and Morse hand key.

When the arc was in operation and the Morse key closed, the movable relay armature made contact with the bottom of the antenna loading coil and the R.F. flowed to the antenna circuit. When the key was open, the relay armature rested on the contact connected to the shunt circuit, which acted as a dummy load. The relay was adjusted so the movable contact was making connection with one stationary contact before it was disconnected from the other, which permitted the arc to remain in constant operation while it was transferred from the antenna circuit to the back shunt circuit and viceversa.

Due to the strong interfering signal from the arc feeding in to the receiver, the arc had to be stopped in order to listen to the station in contact with; not much of a problem, well trained wireless operators could put the arc in to operation in a few seconds. The antenna was switched to SEND or RECEIVE or GROUND by means of a 3 position knife switch.

Coupled compensation. FIGURE III.

Consisted of a single turn of wire placed around the lower end of the antenna loading coil, which could be open or close by means of an auxiliary hand key. With the arc in operation, Morse key closed and auxiliary hand key open, the R.F. energy was radiated at certain wavelenght. By closing the auxiliary hand key the energy was radiated at shorted wave-

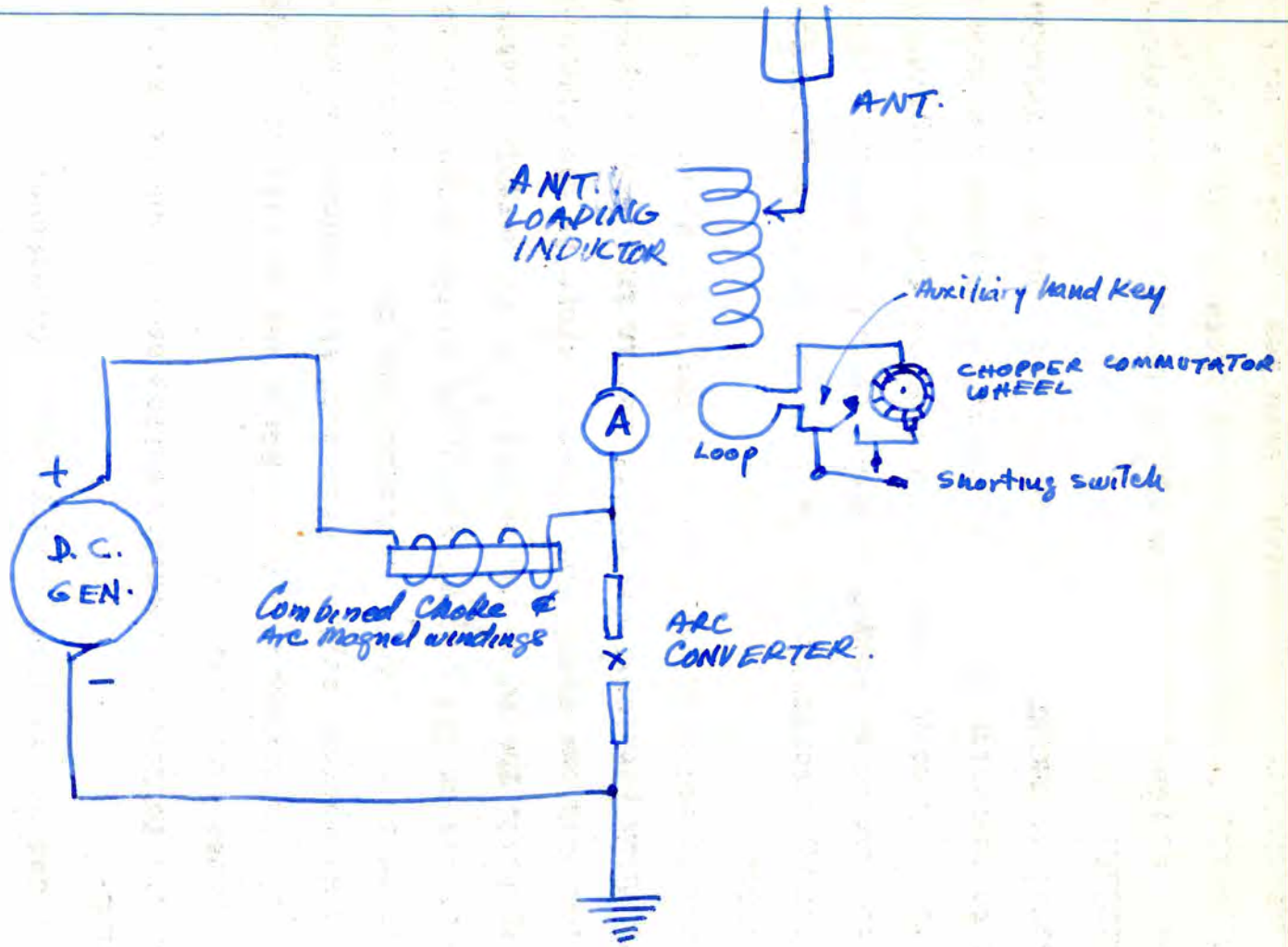



FIG. IV. - FEDERAL ARC RADIO TRANSMITTER. CHOPPER METHOD.

-length, due to the mutual inductance between the antenna coil and the loop and transformer action.

Radio frequency energy was thus radiated at two different wavelengths or frequencies; the receiving station tuned for shorter wavelength (higher frequency) which was the one used to transmit signals with the auxiliary hand key.

Chopper. FIGURE IV.

In transmitting to a station which used a detector, it was necessary to modulate the R.F. energy in order to allow the receiving operator to copy the aignal at an audible frequency. This modulating of the carrier (ICW) was accomplished by means of a chopper, which consisted of a commutator wheel drived by an small electric motor.

When the commutator wheel was in rotation, it opened and closed the coupled compensation loop at certain speed, which provided a musical note in the receiver. The R.F. energy was thus emitted at two wavelengths or frequencies, as when using the auxiliary key, but in this case the walength rapidly alternated between the maximum and minimum value. A continous musical note was produced which could be heard by receivers using simple detector circuits.

Signals could be transmitted either by means of the auxiliary hand key conected in series between the loop and the chopper or by means of the backshunt circuit. When the auxiliary hand key was used, the R.F. energy was broken in to trains of audible frequency, but only during the intervals that the key was closed. When the chopper was used with back shunt method, the auxiliary key was shorted with a small lever switch.

Ignition method. FIGURE V.

Figure V. shows the main circuit used by the ignition method. Besides the usual carbon and copper electrodes, two more electrodes were housed inside the arc chamber. One stationary and insulated from the chamber and the other a movable copper rod, controlled externally by a electromag-

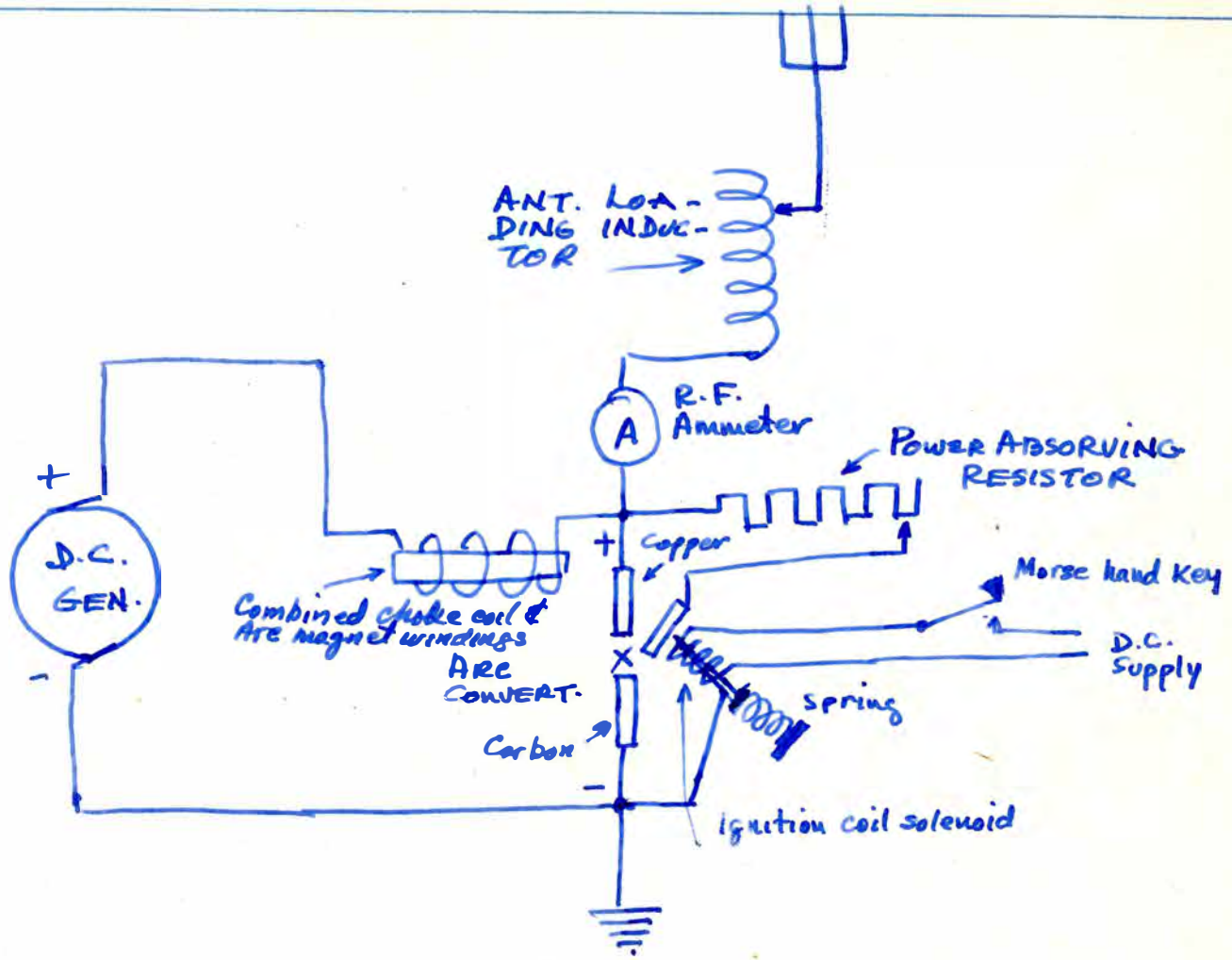



Fig V. - Federal ARC RADIO TRANSMITTER.
IGNITION KEY METHOD.

net.

When these two electrodes were in contact the arc was shunted by the power absorving resistor and the arc extinguished, when the contact was broken the flame which resulted was blown by the magnetic field in to the gap between the two main electrodes of the arc converter, causing the arc to re-ignite and the R.F. to pass to the antenna circuit. Keying was done by moving the ignition key electrode in and out, following the short and long impulses impresed upong the electromagnet by the hand key. A spring holded the electrode closed, the arc extinguished and the D.C. power on the power absorving resistor, and the unit was off until the key was activated.

The power absorving resistor was variable, and adjusted so the D.C. converter output remained constant wheter the arc was operating or not, providing an stable load, similar to the antenna circuit when the arc was active.

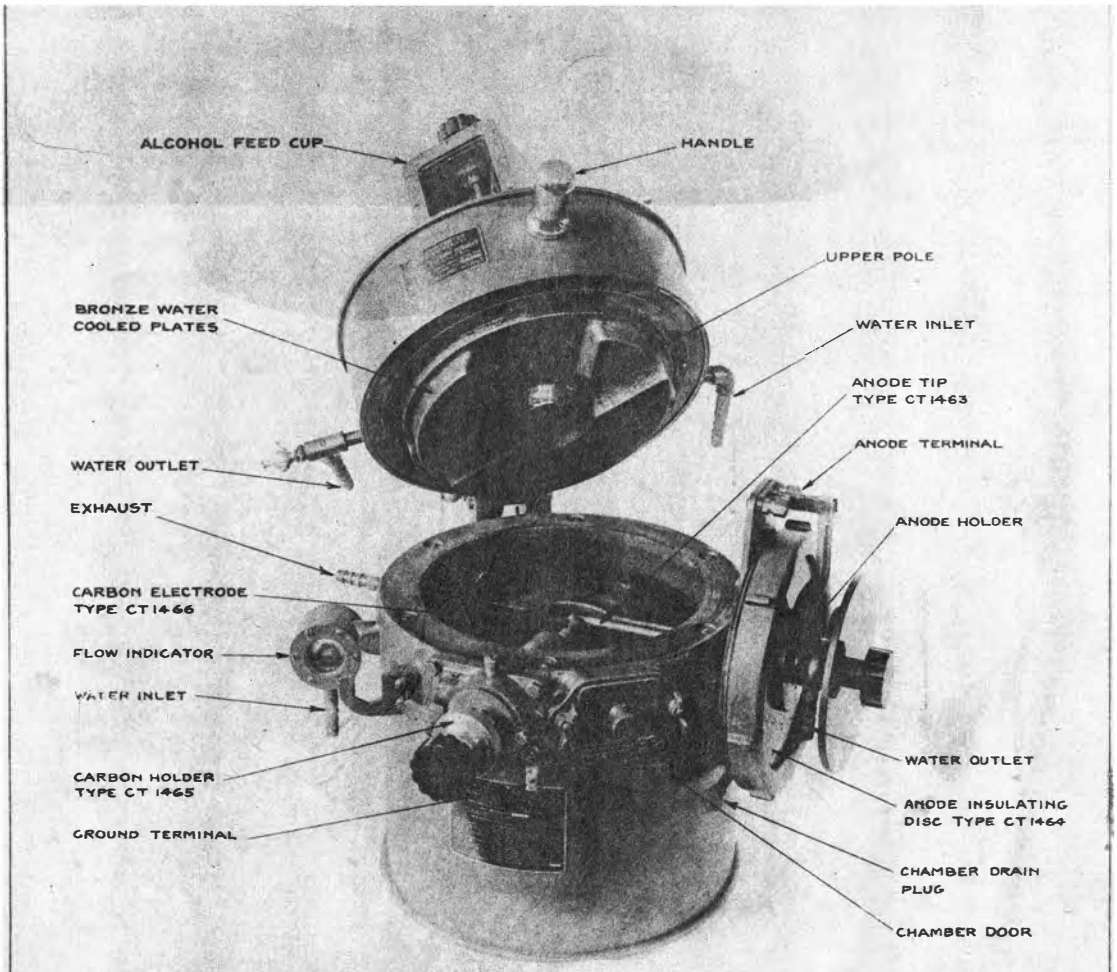
The arc transmitters were in operation for several years, even when commercial tube sets were in ~~operation~~ Function and available in the market; they gave a "good run for their money" to the more sophisticated competitors; until around 1935 when International Agreements prohibited their use. Attemps to voice modulate the arc sets were meet with fair success.

A wireless operator of that vintage told me, that the chamber when dirty, used to "blow the lid off" spraying black soot all over the radio shack, reason why some shipboard "Sparks" used to strike the arc by pushing the starter knob with a broomstick. (Also that the alcohol often dissapeared from the radio shack).

All in all, they were a marvel of scientific achievement and an impressive monument to its inventor the Danish Proffessor Poulsen.

Radio amateurs did not made much use of the arc transmitters, jumping from Sparks to Tubes; perhaps the installation of these "monsters" was too complex and required electric and mechanical components beyond their reach.

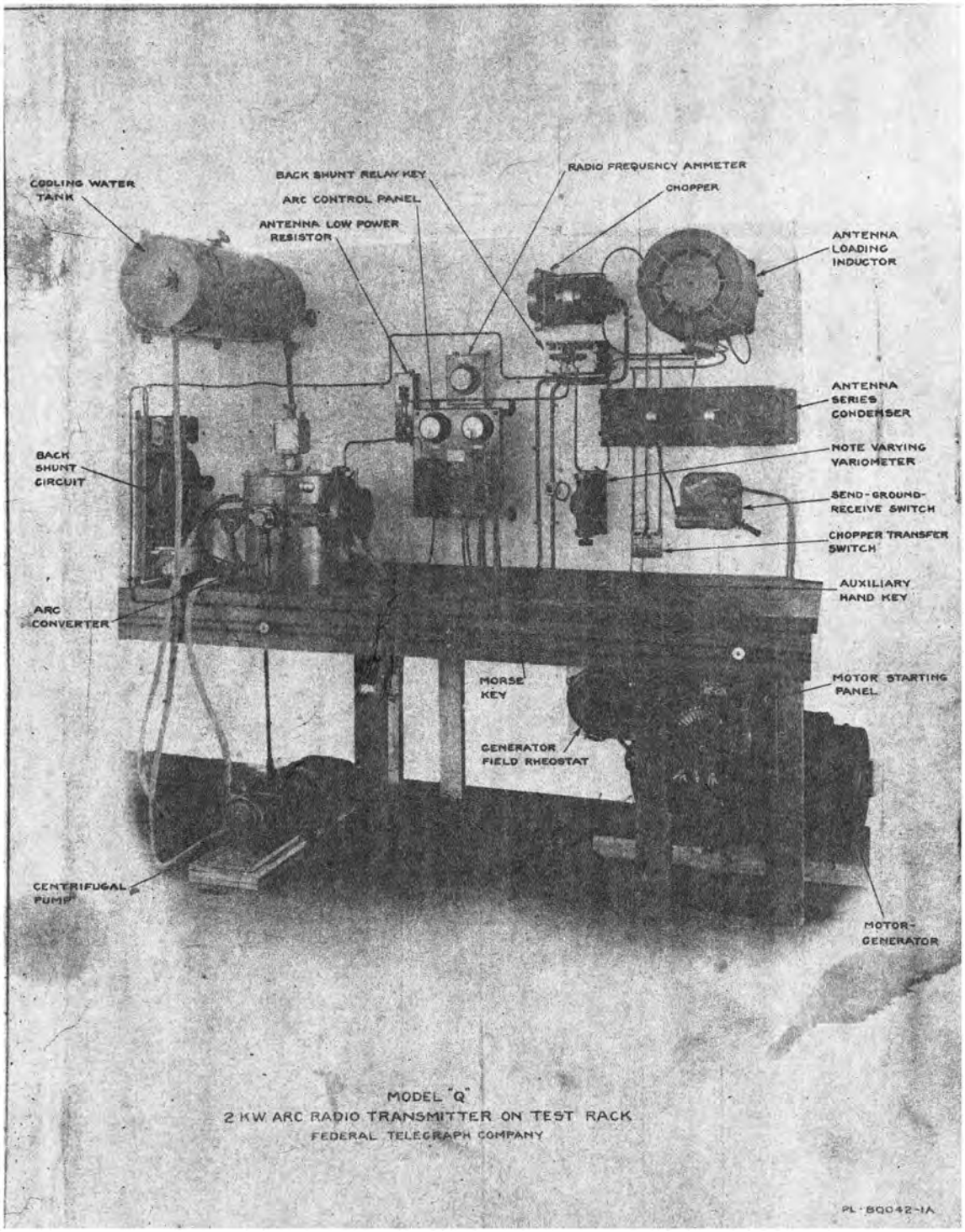
---




2 KW. ARC CONVERTER

TYPE CT 1461

FEDERAL TELEGRAPH COMPANY




MODEL "Q"
2 KW ARC RADIO TRANSMITTER ON TEST RACK
FEDERAL TELEGRAPH COMPANY

PL-8Q042-1A

Far Rockaway, N.Y.
September 15th 1971.

SOCIETY OF WIRELESS PIONEERS
P.O. Box 530
Santa Rosa, Calif.

Attn.; Bill Breniman, Editor.

Dear Bill;

After receiving a letter from John N. Elwood welcoming me into de S.O.W.P. as member No. 878-PA, I felt that my cooperation may be useful, so I decided to mail to you the enclosed article. Although I sailed as "Sparks" for about 20 years I never had the honor of meeting face to face with one of these are babies. However, I was extremely curious in knowing what made them "tick". My first ship was equipped with RMCA M.F. & H.F. 50 watters, and the M.F./L.F. receiver was the IP-501A with 3 01A tubes. Few small spark sets I have operated as emerg. transmitters (actually I have one in my basement now, complete minus the M.G. set);,which I am willing to donate to the S.O.W.P. provided you fellows pay for the freight to California, O.K.?

Imagine which was my surprise about 7 years ago when I started working as M.S.E. for ITT Mackay Marine in N.Y., when browsing thru some old files I found the 2 KW Arc Manual, on which I base the article. At the time I used to belong to the Far Rockaway Amateur Radio Club and they published it in their bulletin "The Ground Wave". But I feel that wireless men, could appreciate much more the bygone smell of ozone, that I intented to bring back; so here it is.

I expect to mail to you shortly some Coast Stations, Ship.s; Alphabetic, Special Services (Berne), since when the new publications come in to Mackay the old ones are just thrown away. If they don.t mind 1 or 2 years old at the S.W.P. QTH.

If you fellows are interested in the small spark set, please let me know and we shall make arrangements.

73

Louis R. Mateo
WB2MVK SWP 878-PA

1204 Augustina Ave.
Far Rockaway, N.Y. 11691

Oct. 27 1971

Dear Lou:

I was not able to tell many of our members that I would be taking a vacation through Sept. and part of October, hence I did not get your letter until my return last week.

I regret the delay in acknowledging and answering yours of Sept. 15th but on that particular day I was out giving the salmon a go for their money up on Vancouver Island. Did quite well too, and hopefully, recharged bats. for the season ahead.

Thanks for the story on the ARC which you have furnished. I will try to use it in an early issue of POC or WP. The next one I am working on has about all it will take in material now scheduled so questionable as to whether I can get this in. However, nice to have on hand for future use and it probably won't be too long.

Incidentally looking at me from my wall is a "ARC CERTIFICATE" issued to me Nov. 9 1921 by the Pac. Radio School. I had to have it endorsed on my license as I went out on a comb job with both arc/spark - KOZC.

Again Lou, thank you very much for your time and effort which are indeed appreciated.