BNL-104458-2014-TECH

AGS/AD/Tech Note No. 17;BNL-104458-2014-IR

DETAILS OF THE OXIDE CATHODES USED IN THE AGS DUOPLASMATRON SOURCE

H. Wroe

March 1966

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, L.I., N.Y.

AGS DIVISION TECHNICAL NOTE

No. 17

H. Wroe

March 29, 1966

DETAILS OF THE OXIDE CATHODES USED IN THE AGS DUOPLASMATRON SOURCE

1. Introduction

The cathode used in the duoplasmatron source is of the directly heated type with a coating of barium and strontium oxides. It has been developed from a design by Dr. L. Oleksiuk who based it on a mercury vapor tetrode cathode (RCA type 672-A).

The special tools and jigs used in the construction have been designed and made by G.R. Rackett, who has also made all the cathodes used to date.

2. Construction of the Cathodes

The general arrangement of the cathode is shown in Fig. 1. The oxide coating is carried by a strip of nickel gauze, wound into a bifilar filament and spot welded to two nickel rods which form the filament current leads. The passage of about 25A (ac) through the gauze is sufficient to raise its temperature to the operating level of 900-1000^{o}C when the power consumed is about 60 watts, see Fig. 3. This comparatively low power consumption is achieved by the use of a nickel can surrounding the filament which acts as shield, enormously reducing the power radiated from the filament. The shield is supported from the nickel rods with two ceramic insulators at each end, as shown in Fig. 1. The insulators are kept in place by nickel ferrules which are spot welded to the rods, so that there is no mechanical force on the guaze itself.

There are two reasons for the bifilar arrangement. First, it makes the nickel rod symmetrical about the axis and conveniently spaced for the connection to the cathode mounting flange. Second, it tends to minimize the magnetic field produced by the filament current which can affect the arc discharge in some circumstances.

The cathodes are spot welded together in nickel, using an Ewald model WHD 4F welding head and a model P30-10S6 power supply. Copper alloy electrodes, 1/8-in. diameter, are used for all the welds and the power supply is set to the 50 watt second range. All the welds used are shown in Fig. 2 and are numbered, the settings of the power supply for each one being shown in Table I.

Table I

Weld No.	Power Supply Voltage	Electrode Pressure lbs.
1	220	5
2	900	20
3	700	20
4	550	10

Figure 2 also illustrates the sequence of operations in the assembly of the cathodes. The filament is first made from a strip of nickel gauze with the ends folded over and welded as shown. This is next formed into its bifilar form using a special jig and is then welded to the 1/16-in. diameter nickel rods between the ferrules as shown in Fig. 2, at which stage it can be coated.

The coating mixture is first thoroughly mixed by revolving the bottle on motor-driven rollers for several days, though whether such a lengthy mixing is really necessary is not yet determined. The filament is dipped into the mix, drained and dried off by placing it about 10-in. away from a 250 watt infrared lamp for half an hour. This is repeated three times to build up a suitable thickness of the coating.

The outer cylinder of the can is rolled from 0.010-in. thick nickel sheet, spot welded as in Fig. 2, and the end caps punched out from the same material using special tools. The filament can then be assembled with the can using the ceramic insulating bushes.

The nickel parts are washed in acetone and the construction of the cathode is performed wearing cotton gloves, but more stringent cleaning processes like hydrogen firing do not seem to be necessary.

A list of the materials used along with the source of supply and the order number used is given in Table II, so that if any unusual results are found in the future, it should be possible to trace the origin of the components.

Table II

Component	Material	Source of Supply	Order No.
Radiation shield 82 ferrules	0.010-in. thick grade A nickel sheet	Varlacoid Chemical Co.	070-732
Filament	Grade A nickel gauze 0.004-in. diameter wire, 50 mesh	" "	087-045
Filament current leads	Grade A nickel rod 1/16-in. diameter	" "	57167-AGS
Insulators, dwg. No.	Ceramic	"Alsimag" American Lava Corp.	082393-AGS
Oxide coating	Proprietary RCA mix Lot No. 248-405-2 April 6, 1962	RCA	

3. Activation

The strontium and barium carbonates in the coating are first converted to oxides by raising the cathode temperature in vacuum, considerable amounts of gas being evolved in the process. This may be done in the source itself, in which case it may take 10-15 hours because of the slow pumping speed of the anode aperture and the procedure is simply to raise the filament current slowly so that the pressure in the arc chamber does not rise above 200 microns. When the current reaches 25 A, the source is left to pump out until the pressure has fallen to less than 10 microns. At this stage, hydrogen is admitted to the working pressure of 200-300 microns (gauge reading) and the discharge voltage pulses are applied.

Activation of the coating seems to be automatic with this procedure, and in almost all cases, a discharge current of tens of amperes can be obtained immediately. In a few cases, the discharge was not seen until 10-15 minutes after applying the discharge voltage.

Once activated, the cathodes can be exposed to the atmosphere several times without harm. The vacuum system is filled with dry nitrogen, but there

is no evidence that this is essential as far as the cathode is concerned. The reactivation is usually completed within an hour once the cathode has been exposed to the atmosphere, provided the exposure was short, say less than half an hour. R. Amari is working on a transfer chamber which will eliminate this delay. The device is basically a small chamber into which the cathode can be withdrawn, in vacuum, and then sealed off with an all-metal gate valve, so that the source can be let up to atmospheric pressure for experimental purposes, or the cathode can be transferred to another source altogether without, at any time, exposing it. It also incorporates a bypass vacuum connection between the arc chamber and main vacuum system, so that the former can be pumped out quickly without the restriction on pumping speed imposed by the anode aperture. Vacuum seals are metal "O" rings throughout and the device is completely "clean", from the vacuum point of view.

Cathodes intended for use on the AGS machine are activated in a separate vacuum rig and kept under vacuum until required. Hydrogen can be admitted to this rig and a discharge operated in the normal way, so that the cathode is fully proved before use in the AGS.

4. Performance of the Cathodes

The operating temperature was measured by observing the cathode through the orifice of a dummy intermediate electrode, placed in a bell jar, with an optical pyrometer, the results being as follows:

Filament Current A	Gas Pressure mm Hg	Temperature ^{o}C
25	$<10^{-4}$	900
25	200 microns TC gauge reading	850
30	$<10^{-4}$	1000

The temperatures quoted are the readings of the optical pyrometer and no corrections have been applied for the emissivity of the filament or the absorption of the glass wall of the bell jar. The true temperatures could be up to $100^{o}C$ higher.

The power consumption of the filament and voltage drop as a function of current are shown in Fig. 3. A cathode was tried without the radiation shield, but the radiated power increased so much that even with a filament current of 40 A, the temperature was not high enough to complete the activation process.

The performance of the cathodes with the Mark I duoplasmatron source has been quite satisfactory and they have proved reliable and long-lived, though no definite figure can yet be given for the useful lifetime. Discharge currents between 25 and 30 A can easily be obtained for periods of continuous operation well over a month. No cathode has yet shown failure of emission during normal operation, though one case has been observed after seven weeks operation when the preinjector was accidently let up to atmospheric pressure while the cathode was hot. It seems that lifetimes of two to three months may well be obtained.

The operational experience just quoted was obtained with an earlier version of the cathode in which the upper ceramic insulators (Fig. 1) were absent. The disadvantage of this construction is that the radiation shield can come loose in service and may touch the filament. The addition of the upper insulators makes a much more rigid assembly, which has performed well on the test stand, but has not yet been used on the AGS preinjector. It is not expected that it will have a performance inferior in any way.

5. Conclusions

The construction of oxide cathodes is mechanically robust and they have been reliable in operation, both in test stands and on the AGS machine. Too little experience has yet been obtained to be able to give a definite figure for the useful life of the cathodes, but it will probably be over two months continuous operation.

Distribution: AGS Division Staff

HW/ah

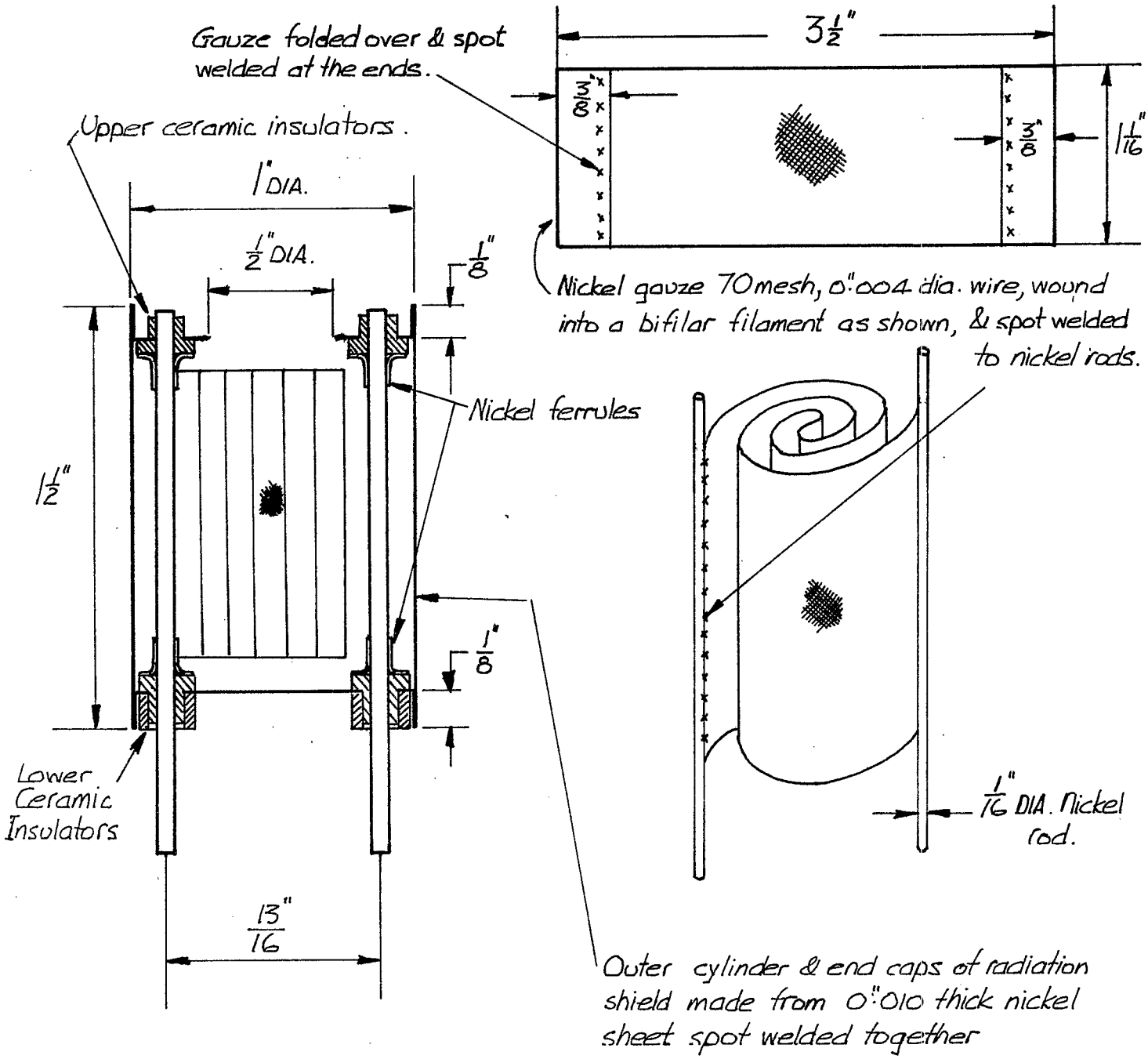
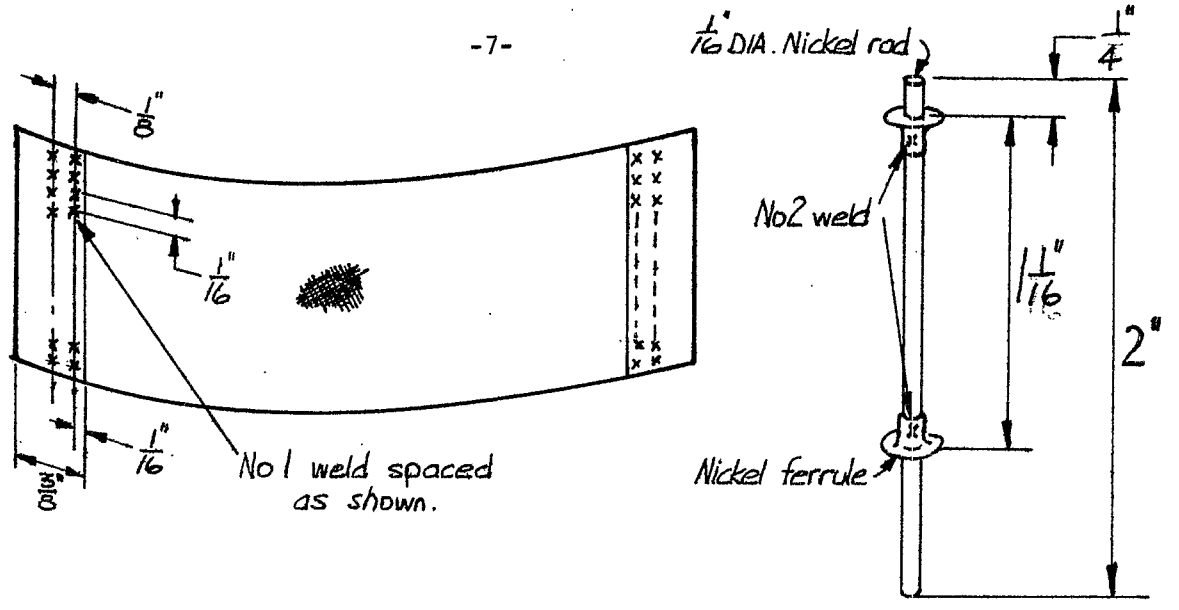
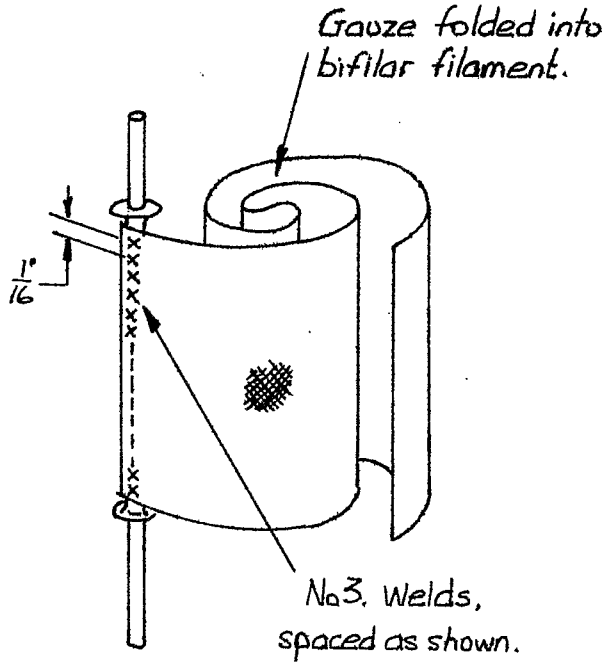
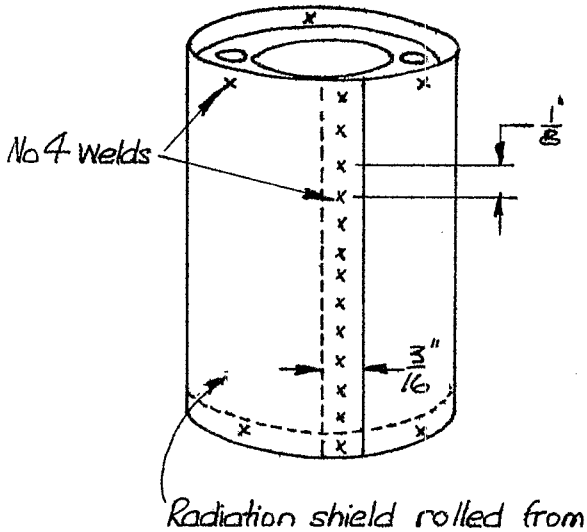


FIG 1 Mechanical construction of Mk II oxide cathode for Duoplasmatron Ion Source

H. Wroe. B.N.L.
March 66.







Radiation shield rolled from 0·010 thick nickel sheet, overlapped 3/16".
End caps punched out of 0·010 nickel sheet & tacked on with 3 No 4 welds.

FIG 2 Details of spot welds used in construction of MkII cathodes.

H. Wroe B.N.L. March 66.

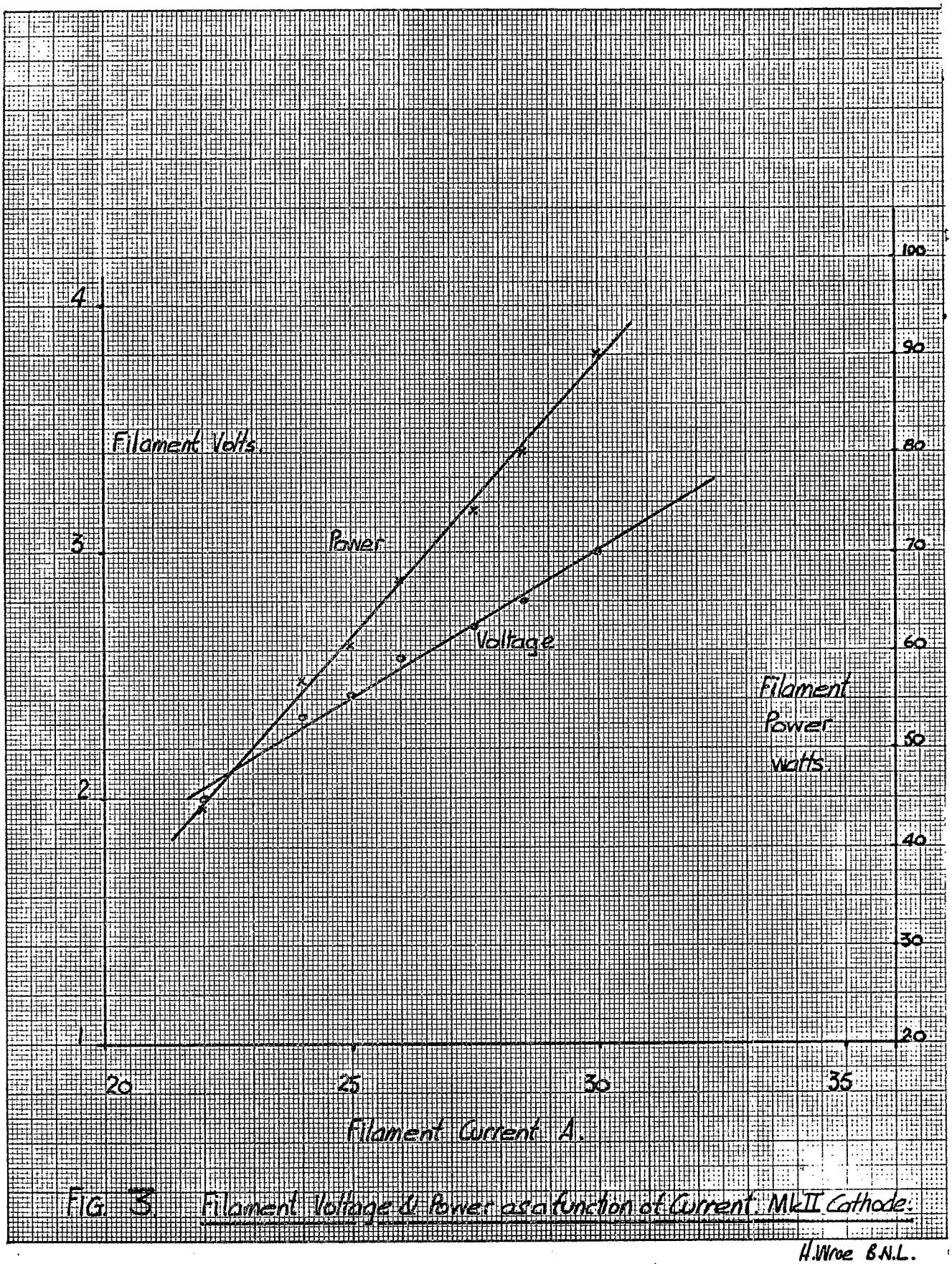


FIG. 3. Filament Voltage & Power as a function of Current. MkII Cathode.

H. Wroe B.N.L. March. 66.