DETERMINATION OF THE DEFECTS IN A GENERAL ELECTRIC ARC-WELDING GENERATOR

BY

R. D. ELAM

AND

O. D. RISEDEN

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Introduction

This subject was undertaken as a thesis for the purpose of determining why a belt-driven General Electric Arc-Welding Generator would not operate satisfactorily. In previous operation of this machine there appeared to be no residual magnetism in the pole-pieces. When the machine was brought up to speed, there was only a small voltage produced as indicated by a volt meter connected across the brushes.

Actual Work

The bearing housings were removed and the windings of the armature and field examined to determine the manner in which they were connected. The armature was tested for grounds and short circuits, by use of a battery and a volt meter. No ground or short circuit was found in the armature. The shunt winding and series winding were also tested. There appeared to be no damage to the windings and their connections. However, several of the leads from the shunt field were badly corroded, which necessitated their being cleaned and resoldered.

The residual magnetism of the pole-pieces appeared to be sufficient for the machine to operate at rated voltage.

The generator was mounted in such a manner as to be belt-driven by a twenty horse-power three phase induction motor. With the generator connected as shown in Figure 1, separate excitation was applied to the field. The series winding is supposed to "buck" the shunt winding, that is, the Magneto Motive Forces set up by the two coils are in opposite directions. When the machine was put into operation, the volt meter connections had to be reversed from their position on the panel. As soon as an arc was struck,

the voltage began to build up instead of dropping to a value between twenty to twenty-five volts. The voltage increased according to the position of the series field switch. This action is contrary to that under which the machine is supposed to operate. From this action the conclusion was drawn that the series field was assisting the shunt field instead of bucking it. The field connections were then reversed and the machine operated in a satisfactory manner. After the machine had been run as a separately excited unit for some length of time, the current was disconnected from the field. The generator continued to operate at rated voltage with the required drop in voltage when an arc was struck.

After two days of idleness an attempt was made to bring the voltage of the machine up to that required for welding. The attempt was unsuccessful, for no voltage was indicated by a volt meter when connected across the brushes. As soon as the field was excited by a two-volt battery, the volt meter immediately indicated rated voltage. The instant the machine was short-circuited, the voltage dropped to zero. On removal of the short-circuit, the voltage was built up again, after the machine had run a few minutes without load. When the terminals were again shorted, the voltage dropped to zero and would not build up until separate excitation was again applied to the field. Several

methods of correcting this result were tried. Finally, the shunt field connections were changed. The terminal which had been originally connected to the third brush was interchanged with that connected to the first brush in a clockwise direction of rotation, as seen from the commutator end of the generator. The voltage immediately built up to rated voltage and would drop to twenty-five volts at welding. The only conclusion arrived at from this investigation was the fact that the shunt field connection might possibly have been reversed before the generator left the factory or changed when the unit was first installed.

No satisfactory results could be obtained by a test on this machine, due to the belt slipping on the driven pulley. For any position of the series field switch, the ammeter indicated approximately the same current when it should have varied from seventy-five to two hundred amperes.

It is believed that satisfactory results can be obtained by direct connection of this generator to a constant speed motor, as in the case of the more up-to-date machines described in the following pages.

General Theory

A suitable arc is essential to successful arc welding. The production of this stable characteristic requires some means of regulation. When each welder is furnished with an individual generator the necessary regulation is in most cases placed within the generator itself. However, there are some companies who build machines with the inductance separate from the generator unit.

A large amount of work has been done to produce direct current machines which have inherent regulation. The simplest and most successful machines having internal regulation are the compound wound direct current generators and motors. The compounding may either be cumulative or bucking. The cumulative compounding winding is used to maintain a constant potential in shunt-excited generators. It is also used for motors to give characteristics lying between those of shunt and the series motor. Differential compounding or bucking produces unstable conditions in generators except when they are separately excited. The compound winding owes its success to the fact that it can be applied to direct current machines without any structual change whatever. However, there are many problems in direct current engineering that require gen-

erators having inherent characteristics which compound windings cannot give. In the past a great number of attempts have been made to produce machines of such regulation, but none have met with any amount of success. The main reason for this failure is the difficulties which arise from commutation. The introduction of the commutating pole has helped direct current machines probably more than any one thing, because it is by this method that we nearest approach perfect commutation.

Description of Different Types of Machines

General Electric

Some years ago S. R. Bergman who was consulting engineer for the General Electric Company designed "a direct current machine with a dual magnetic circuit". This machine has an open circuit voltage of sixty and an arc voltage of twenty. On the particular machine tested there were six current taps on the series field so arranged as to give 200, 175, 150, 125, 100 and 75 amperes at 20 volts. This regulation is obtained by cutting in or out the windings of the series field. The shunt field is bucking the series field; consequently, if more turns are added to the series field the current will decrease, because the shunt field remains constant while the series varies. It is by this means that variable current at constant voltage is secured.

The armature is wound for half the number of poles contained in the field. In this machine the poles are paired in groups of like polarity which makes a group of two north poles followed by two south poles. (See Figure 2.)

The load current of the armature is taken from two brushes "A" and "C" placed in the neutral located be-

tween poles of opposite polarity. As soon as the armature is loaded an armature reaction is set up, whose reaction may be resolved into two components at right angles, "O D" acting in the direction of the main poles and "O E" in the direction of the cross poles. The component "O D" supports the main flux and the component "O E" opposes the cross flux. The main magnetic circuit is so designed that magnetic saturation exists and the component "O D", therefore, cannot force any more flux through this circuit. Hence, the main flux remains constant independent of the load. The cross magnetic circuit, however, is not saturated; therefore, the component "O E" blows out the cross flux which thus decreases as the load increases. If a third brush "B" is placed in the neutral between poles like polarity, it is obvious that the voltage "A B" remains constant, since the conductors on arc "A B" are cutting a constant flux at a constant speed. Advantage is taken of this fact to supply the excitation of the generator from these two points which possess a constant difference of potential and thus secures an inherently stable machine at all loads. The voltage "B C" decreases as the load increases since the conductors of the arc "B C" cut at constant speed a flux which decreases as the load increases. Figure "2" shows the cross flux and main flux entering the armature between the brushes "A"

and "C". Hence, the electromotive force is induced in the same direction along the arc "A B" as the arc "B C". Therefore, A C = A B + B C Volts. Since the voltage "A B" is constant and "B C" decreases with the load, the generator is designed to give sixty volts at no load.

Therefore, A B = B C = 30 volts

A C = A B + B C = 60 volts.

Westinghouse

The Westinghouse like other generators mentioned operates on the variable voltage principle. A separately excited shunt field with a bucking series field furnishes the exitation. The shunt field exitation is furnished by an exciter on the A-C driven set and from the power line on the D. C. driven set. The shunt field establishes the open circuit voltage which is controlled by a rheostat in series with the shunt field circuit. When the arc is struck, the bucking series field reduces the generator terminal voltage to a value equal to the arc voltage. This rapid voltage change in the generator is secured by proper design of the generator field. This response is obtained by the use of laminated poles and proper proportioning of the reactance. A small reactor with low inductance is used to secure arc stability to a degree consistant with good welding current, which is controlled by a single dual field rheostat. The operator can quickly set the welder to any current over the range from sixty to three hundred amperes.

Lincoln

The variable voltage was obtained by a differentially compounded field consisting of a separately excited shunt field and a bucking series field. The shunt field governs the open circuit voltage which is varied by rheostat to adjust welding current. The shunt field takes exitation from a small exciter on the A. C. set. In addition to the shunt field rheostat a multiple knife switch is used to vary the bucking effect of the series field. This diverter switch throws steps of resistance in shunt with the series field. This adjustment is independent of open circuit voltage.

Hansen

The generator operates on the variable voltage principle. This is obtained by a self excited shunt field from the brushes and a bucking series field. The control of welding current is maintained by a brush shifting device. By this means of adjustment, due to the short distance that the brushes are moved, it is difficult to predetermine exactly the current setting desired. No external reactor is used with this unit. The reactance necessary for this set is secured by means of a complicated field winding within the generator frame. The current of the commutating pole coils are completely embedded in the adjacent main pole flanges. With this arrangement simplicity has been sacrificed in order to gain a saving in weight.

Una-Weld

The welder is of a dynamotor type having a common armature for both the motor and generator. The generator is separately excited and cumulatively compound wound. The welding current is controlled by means of a field rheostat in the shunt field and a resistor in series with the arc. The different steps of resistance are cut in and out of the welding circuit by means of a rotary switch. Also, an external reactance is used to stabilize the arc. This machine will deliver constant current, irrespective of the temperature change.

There are three types of the Una welder, namely,

Single operator types B J and D-4

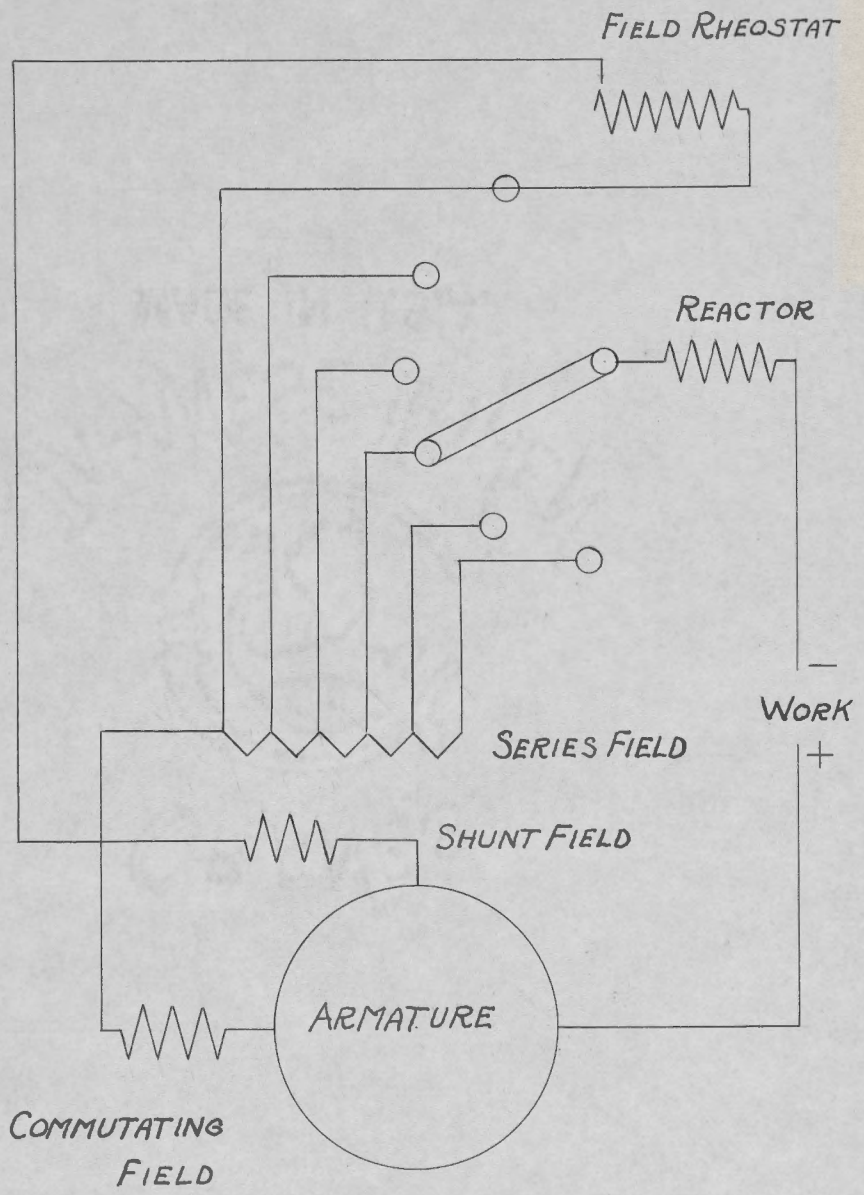
Double operator D-4.

In the single-operator machines the arc adjuster is divided into two parts, one controlled by means of knife switches and the other by a ten point dial switch mounted on the same panel. The knife switches give steps of approximately fifty amperes regulation to the welding current, while the dial switch is used for exact regulation of the welding current, giving ten steps of five amperes each for each position of the knife switches. The current adjustments between fifty and three hundred amperes on the type "B J" and fifty to five hundred amperes on the

"B-4" may be obtained in forty and eighty steps respectively.

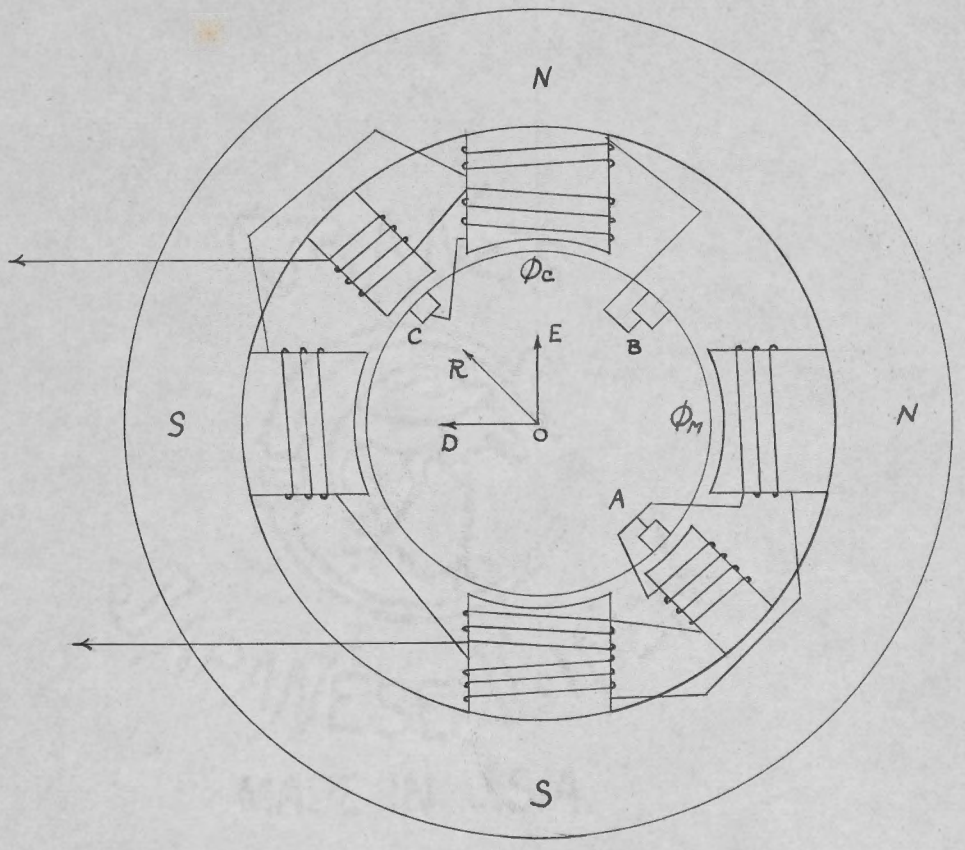
The type "B-4" Double operator has two arc adjusters, each with a current range of fifty to two hundred twenty-five amperes. The connections are similar to those described on the type "B J". Forty steps are provided for each operator. The work of one has no effect upon that of the other.

FIGURE 1



SCHEMATIC DIAGRAM G.E. TYPE
ARC WELDING GENERATOR

FIGURE 2



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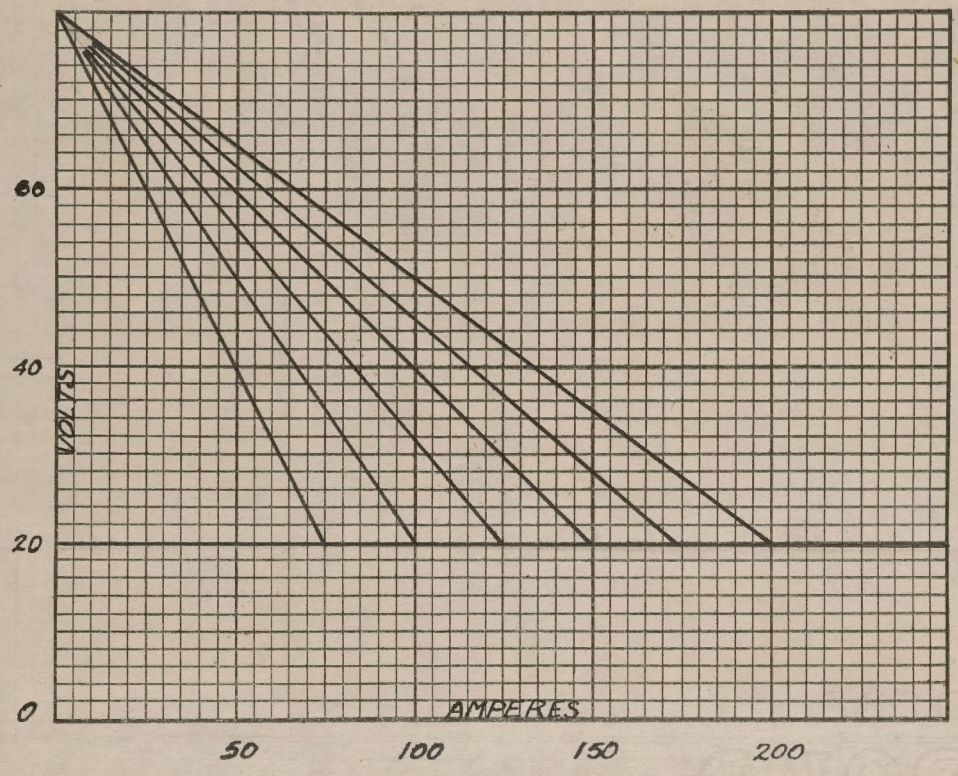


FIG. NO. 3

TITLE:- FACTORY CHARACTERISTIC CURVES

ON G.E. 3-BRUSH GENERATOR

INTERPRETATION OF CURVES

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Approval

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

Name J.G. Tarboux

Title Prof Elec. Eng