CLINTON ENGINEER WORKS - TENNESSEE EASTMAN CORPORATION

AECD-3781

Process Improvement Division - Report

(TK-B-3- #1)

TITLE: A New Type Regulator for High Voltage Supplies

ABSTRACT:

AECD-3781

A voltage regulator useful for regulating the output voltage of high voltage power supplies is described. Some of the advantages of this new type regulator are:

1. The entire regulator drawing small amount of current from the regulated supply. The current will be about 2 ma.
2. Extension of the principle of this regulator makes it applicable for power supplies ranging in output voltage from perhaps a kilovolt to more than ten kilovolts.
3. The regulator may be arranged to have very good long time DC stability to such an extent that the output voltage will not change more than a small fraction of a percent over periods of hours.
4. The regulator may be arranged to have very good short time stability and in this way will regulate very quick changes in the input voltage.
5. Items 3 and 4 are accomplished by using variable loop gains and time constants. In either case the loop gain is considerably higher than present time conventional regulators.
6. By proper arrangement of the circuits the regulators may be used to regulate the output voltage over ranges of four to one. In any event the regulation at different parts of the range will be found to be very good and substantially constant, a desirable characteristic not found in ordinary regulators.

AUTHOR:

E. J. Groth, Jr.
Building 9706-2

This report was prepared as a scientific account of Government-sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights. The Commission assumes no liability with respect to the use of, or from damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Photostat Price \$ 1-80

Microfilm Price \$ 1-80

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

A NEW TYPE REGULATOR FOR HIGH VOLTAGE POWER SUPPLIES

During some work recently undertaken it was desirable to have a source of high voltage continuously variable from about 1600 volts to about 4000 volts. It was essential that this voltage be well regulated both from the long time stability angle and also from the short time angle. It was essential that pulses originating in the power supply be less than about one millivolt. It was desirable that the output voltage vary less than about 5 volts over long time intervals. It is possible to design a regulator that will meet such requirements but in general, they turn out to be rather complicated affairs if good engineering practice is observed. Usually such regulators are designed to use a battery standard if not a voltage regulator tube and the battery is floated at high potential above ground in a negative grounded supply. Another feature not found desirable was that usually a rather large direct potential will appear across one of the tubes in the regulator amplifier. In the present case the potential would be about two to three thousand volts and this is undesirable from the standpoint of continuity of operation. It was decided that what was needed was a new type of regulator and the following system was evolved.

The schematic diagram shows the regulator including the regulating tube and the direct current amplifier along with the method of controlling the output voltage and the voltage regulator tube standards. The direct current amplifier is of primary interest as this is the heart of the new system. The amplifier consists of three double triode tubes operating in cascade with a common total current flowing through each double triode. The triode at the bottom of the chain has one grid controlled by the output voltage and the other grid controlled by a standard voltage obtained from three VR 150's in series. This tube has a common cathode resistor and this is un-bypassed so that when a signal is applied to the grid controlled by the output voltage a very nearly equal signal of opposite sign is applied to the standardized grid. This is accomplished by a slight cathode-ground potential change in this tube. The output of this first tube is then applied to the second tube in the chain and further amplified. The thirty thousand ohm resistors used for plate loads in the first and second tubes serve to supply bias for the second and third tubes of the chain. The output voltage of the direct current amplifier is taken from the plate of the third tube and applied to the grid of the 809 regulator tube in the usual manner.

The standard voltage is obtained from the voltage regulating tubes operating in their low current range from about 250 to about 850 microamperes. An LC filter is provided between the standard voltage and the standardized grid to prevent pickup by this grid of any variations in the output voltage as such variations would have an effect opposite to those picked up by the other grid of the first triode. The output voltage is varied by means of the one megohm potentiometer feeding the controlling grid of the first triode. The control forms part of a voltage divider which is also used as a meter resistor for the 0-1 ma. meter used to indicate the output voltage.

If it is desired that the regulator have very high long time stability it will be necessary to use the one microfarad condenser shown in dotted lines in the grid circuit of the 809. In this case the resistors connected plate-to-plate in the first and second triodes should be omitted. The condenser will be necessary to lengthen the time constant sufficiently so that the regulator will not oscillate. With this type of connection it will be found that the loop gain of the regulator will lie in the range of 2.5×10^4 to 10^5 . This is an exceptionally high loop gain and means that the output voltage will be very constant if the standard remains constant and if the divider does not change its values. In the present system the divider is made up entirely of wire wound resistors and efforts were made to place the divider and voltage regulator tubes in positions so that

would be very little heating of these components. It has been found that in this case the long time stability of the regulator is better than any convenient method of measuring it.

If it is desired that the regulator be sensitive to small quick changes in load and supply voltage the time constant condenser in the grid circuit of the 809 should be omitted and the plate-to-plate resistors used. Omission of the time constant condenser makes the circuit sensitive to extremely high frequency changes. The frequency range of the amplifier has not been measured but should be substantially constant to beyond 100 kc./sec. The use of the plate-to-plate resistors merely cuts down the gain of the amplifier to a point where it will not oscillate. The values of these resistors should be experimented with in each particular case as their value will depend upon the physical layout of the amplifier. The circuit should be laid out as a wide band amplifier with the usual precautions as regards short leads and stray capacities. The values shown were found to be satisfactory in the present case.

With the regulator connected as explained in the above paragraph the DC loop gain will vary from about 7×10^3 to about 2×10^4 and the AC loop gain will be constant at about 2.5×10^3 . This means that the long time voltage stability will still be much greater than in conventional regulators and that the output voltage will contain very little ripple. In the present case the regulator followed a single section of filter from a half wave power supply and the output was found to contain about 2 millivolts of 60 cycle ripple. For the present application no current was to be drawn from the supply and following the regulator with an RC filter with a time constant of 0.6 seconds resulted in substantially pure direct current output. It will be found that condensers will play an important part at the higher voltages as far as spurious pulses are concerned. To overcome this objectional feature condensers rated at twice the maximum output voltage were used in the subsequent RC filter.

The regulator may be applied to any output voltage and the number of tubes in the amplifier will be determined by the drop desired across each tube. It has been found that about a thousand volts is all that is permissible for steady operation. If more tubes are used in the amplifier the gain of each stage will have to be limited so as to prevent oscillations. This limiting may be accomplished by use of time constant condensers or plate-to-plate resistors or by a combination of both. In any event a separate well insulated filament transformer is needed for each tube.

The range of operation is determined by the range of current that may be tolerated in the VR tubes. It was found that this range may be stretched to about 4 to 1 but not much further than that. Hence the range of operation of the regulator is about 4 to 1 in output voltage. The gain of the amplifier will remain constant over this range within reasonable limits. Hence, the gain of the regulator will remain constant over the rather large range of output voltage. This is certainly not a feature found in other regulators in which the operating current for the amplifier is derived from the voltage to be regulated.

E. J. Groth, Jr.
E. J. Groth, Jr.

Copy 1 Dr. H. L. Hull
W 2 Dr. K. G. Macleish
" 3 Mr. O. E. Miller
" 4-5 Library
" 6-7-8 E. J. Groth, Jr.
" 9-10 File

3a

DETECTOR CIRCUIT.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK