2ND EDITION

Federal's SELENIUM RECTIFIER Handbook

FEDERAL TELEPHONE & RADIO
FTR
DIVISION OF IT&T

FIFTY CENTS

Federal's

SELENIUM RECTIFIER

Handbook

for

RADIO-TELEVISION

and

OTHER ELECTRONIC APPLICATIONS

2ND EDITION

Compiled and Published by

SELENIUM-INTELIN DEPARTMENT

Federal Telephone and Radio Company

A Division of

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

No patent liability is assu ed with respect to the commercial use of the circuits and rectifier information contained in this booklet.

Selenium Rectifiers described in this booklet are manufactured by Federal Telephone and Radio Company under one or more of the following United States Patents:
Nos. 2,241,908; 2,314,104; 2,342,278; 2,359,377; 2,380,080; 2,386,750; 2,392,744; 2,426,242; 2,433,402; 2,434,911; 2,444,473; 2,445,769; 2,450,020; 2,450,886; 2,452,603; 2,485,593; 2,568,764.

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Foreword

Since the publication of the first Federal Selenium Rectifier handbook, many millions of rectifiers have found their way into equipment covering every phase of the electronic field. The broadening of the fields of application has created a demand for many new selenium rectifier types and, quite naturally, a more complete handbook describing their use.

This enlarged second edition includes the majority of selenium rectifiers manufactured by the Federal Telephone and Radio Company for radio, television and other electronic applications. In addition, many new uses for selenium rectifiers are described, as well as some recent developments in Federal's other selenium rectifier products.

The book presents essential data and circuit information so edited as to entail a minimum of cross reference. It is divided into three sections. Section I describes the application, and electrical and mechanical characteristics of each rectifier listed. Section II provides circuit and service information, including many power supply circuits used in radio, TV and industrial equipment. Section III describes other Selenium Rectifier products which may be useful to the reader.

Federal realizes that a book, no matter how carefully it is prepared, can never include all necessary information for such a complex product as the selenium rectifier. Because of this, Federal has always been ready to assist the engineer, designer, or technician in perfecting new circuits or adapting rectifiers to existing designs.

As America's oldest and largest manufacturer of selenium rectifiers, Federal stresses quality, service and reliability. Continuous research carried on by a staff of expert engineers has enabled Federal to develop better rectifiers at lower cost.

Federal Telephone and Radio Company

A division of IT&T

Selenium Rectifier Handbook

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THE DEVELOPMENT OF THE SELENIUM RECTIFIER

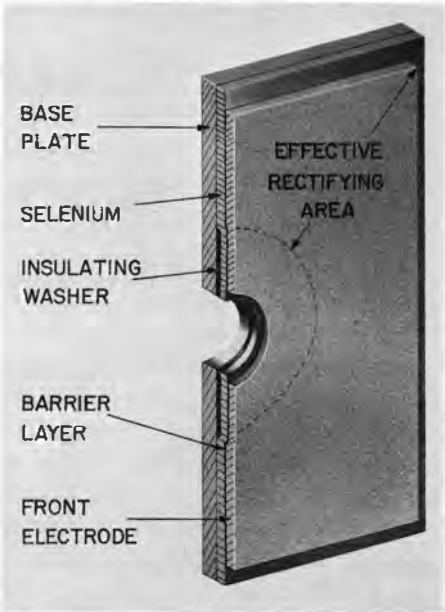
The selenium rectifier was first developed in 1928 by a European associate of the International Telephone and Telegraph Corporation. Its simple, sturdy construction and efficient operation led to immediate acceptance in industrial applications. In fact, within a short period, 88 per cent of all metallic rectifiers used abroad were of the selenium type.

Federal Telephone and Radio Company, a Division of International Telephone and Telegraph Corporation, introduced the selenium rectifier to the American market in 1938. Realizing its potentialities, Federal immediately launched a continuing program of research and development which has meant the extension and improvement of the product and its applications. Federal's achievements in rectifier development have resulted in more-highly rated cells (the latest being 36-volt selenium cells); numerous methods of protection of the rectifier stacks against almost any environmental condition, physical or chemical; and many unique by-products which are aiding in the rapid development of our electronic age.

In 1946 Federal marketed a selenium rectifier stack designed specifically for use in radio and television receivers. Its small size and low cost made it applicable to almost any power supply system in radio and T-V fields, as well as other types of circuits. Since its inception, more than 35 million units have been shipped to the field to replace rectifier tubes, saving space and weight and eliminating costly or scarce components. The four initial models have now grown to more than 25, covering every desired application.

Today Federal continues to lead in the research and manufacture of the selenium rectifier. A program of cooperation between the customer and Federal's engineers assures the constant awareness necessary to continually provide a better product.

SELENIUM RECTIFIERS — WHAT THEY ARE AND HOW THEY WORK

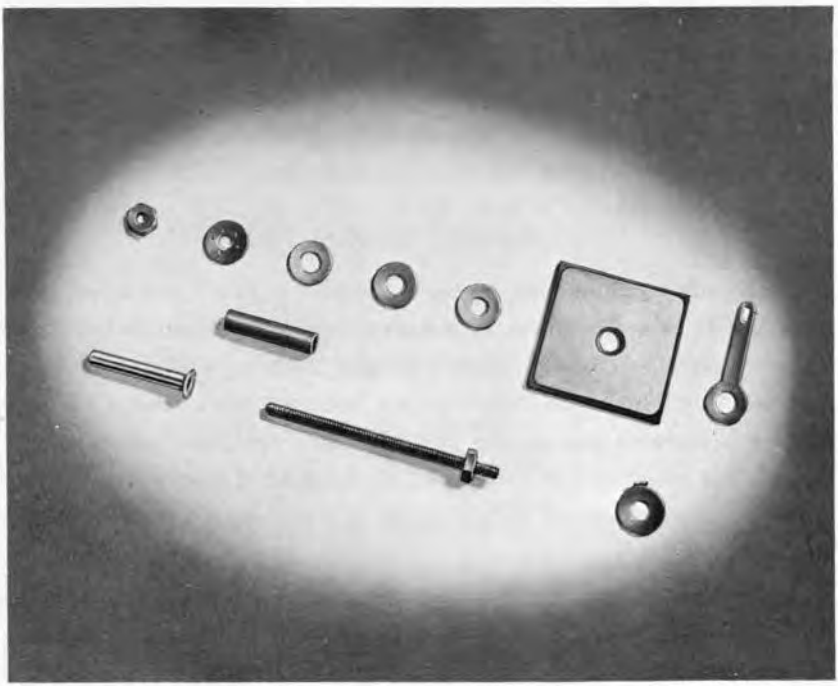


The selenium rectifier is a static device possessing the ability to pass electric current in the forward or conducting direction and offering extremely high resistance to the passage of electric current in the reverse or blocking direction. A cross-section diagram of a selenium rectifier cell is shown on this page. It consists of a front electrode and a back electrode, or base plate, separated by a semi-conducting layer of selenium. Current flows readily from the back electrode through the selenium to the front electrode, but meets high resistance when flowing in the opposite direction.

In the fabrication of the selenium rectifier cells, the base plate is generally aluminum. The metal is chosen for its lightness and ability to dissipate heat. To achieve a firm bond with the selenium layer, one surface of the aluminum plate is roughened either by chemical etching or sandblasting, then usually nickel-plated to give minimum contact resistance. Purified selenium, with addition of bromine, chlorine, or iodine, is applied to the plate and subjected to heat and pressure. The plate then undergoes further heat treatment which crystallizes the selenium, thereby increasing its conductivity.

An artificial barrier layer is applied over the selenium and the front electrode is then sprayed over the barrier layer. This electrode is an alloy which can be formed from several elements, the selection of which is determined by the final ability of the compound to provide a low resistance conducting layer for the current passing from the back electrode, and at the same time providing a strong barrier to the current passing in the direction of the back electrode. A typical front electrode alloy is one composed of tin, cadmium, and bismuth. To further increase the ability of the selenium cell to withstand reverse voltage, a pulsating direct current is applied in the reverse direction while the cell is heated under closely controlled temperatures. This forms the desired barrier layer.

The resulting selenium rectifier cells are assembled into compact stacks consisting of cells, spacers, insulators, and a center stud with or without mounting brackets. Contacts are brought out from the cells in various arrangements for series and parallel connections as required.



Components of a typical Federal Selenium Rectifier

APPLICATIONS OF FEDERAL SELENIUM RECTIFIERS

The selenium rectifier offers many advantages both electrical and mechanical. It is comparatively small and light with a sturdy construction that minimizes injury from shock, vibration or strong pressures. There are no moving parts. These characteristics, together with those listed in the next paragraph, combined with its relatively low cost, make the selenium rectifier an ideal component in the circuits to which it is applicable.

The fields of application of selenium rectifiers have been constantly expanding due to their capabilities of operating over a wide range of voltages and currents, and of providing satisfactory performance under diverse environmental physical conditions. Typical applications range from milliamperes at high voltages to thousands of amperes at relatively low voltages. For instance, it is practical to use selenium rectifiers in a cyclotron application which may require 50,000 volts at 5 milliamperes or in electroplating and electrolysis equipment which require up to 100,000 amperes with voltages in the order of 50 volts, dc.

Selenium rectifiers have found application in heavy and light industries as well as in the home. In industry, they are used in electroplating and electrolysis equipments, fire alarm units, counting and grading equipment, railway signaling, battery chargers, and arc welding units. They are utilized in scientific instruments and laboratory equipment when a reliable, efficient power supply is required. In the field of electronics, they are utilized in tone generators, voltage doublers and magnetic amplifiers.

Selenium rectifiers are found in home radios, portable radios, television receivers, record players, relay power supplies, business machines, electric razors, and many other applications requiring direct current from a 117 volt line.

SECTION I

Federal

SELENIUM RECTIFIERS

for

RADIO-TELEVISION

and

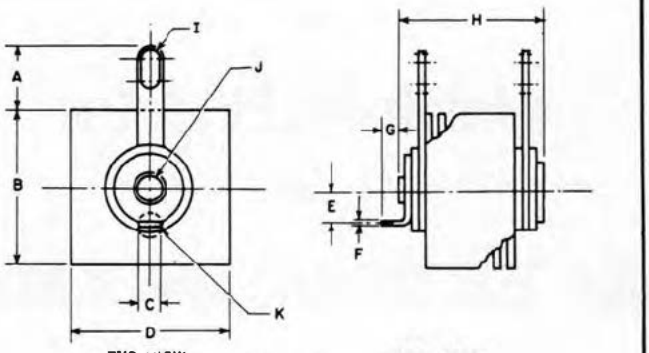
OTHER ELECTRONIC APPLICATIONS

- DIMENSIONAL DIAGRAMS
- DIMENSIONAL TABLE
- FUNDAMENTAL CIRCUITS
- CATALOG OF MODELS
  - Characteristics
  - Circuit Applications

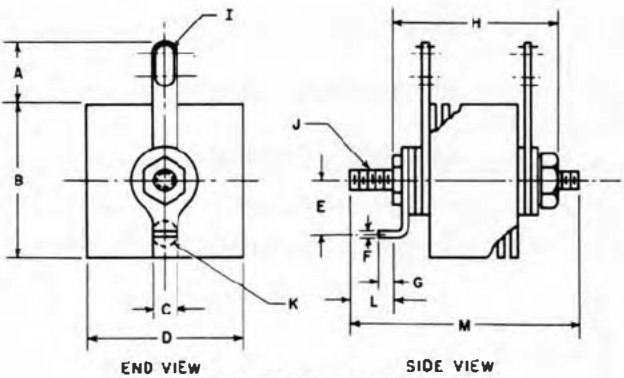
DIMENSIONAL DIAGRAMS

Reference should be made to the dimensional diagrams, Fig. I and Fig. II below, when using the dimensional table given on page 11.

Rectifiers may be obtained with or without the locking lug (affecting dimensions C, E, F, and G). The locking lug provides a convenient method of preventing movement of rectifier after it is installed in the set. When a locking lug is desired, add the letter "A" after the Federal model number (for example, 1004A instead of 1004) when rectifier is ordered.



EYELET CONSTRUCTION
FIG. I



STUD CONSTRUCTION
FIG. II

DIMENSIONAL TABLE — SEE DIMENSIONAL DIAGRAMS PAGE 10

TYPE	FIG. No.	A	B	D	E	G	H (MAX.)	I	J	L	M (MAX.)
1002	I	19/64	1	1	17/64	1/8 + 1/32 — 1/64	9/16	5/64 x 5/32	9/64 DIA.	—	—
1003	I	19/64	1	1	17/64	1/8 + 1/32 — 1/64	3/4	5/64 x 5/32	9/64 DIA.	—	—
1004	I	23/64	1 9/32	1 13/64	17/64	1/8 + 1/32 — 1/64	3/4	5/64 x 5/32	9/64 DIA.	—	—
1005	I	23/64	1 9/32	1 13/64	17/64	1/8 + 1/32 — 1/64	1	5/64 x 5/32	9/64 DIA.	—	—
1006	I	7/16	1 17/32	1 17/32	17/64	1/8 + 1/32 — 1/64	1	3/32 x 3/16	9/64 DIA.	—	—
1007	II	19/64	1	1	21/64	1/8 + 1/64 — 1/16	2 1/16	5/64 x 5/32	6-32 NC 2	5/16 ± 1/32	2 11/32
1008	II	23/64	1 9/32	1 13/64	21/64	1/8 + 1/64 — 1/16	2 1/16	5/64 x 5/32	6-32 NC 2	5/16 ± 1/32	2 11/32
1009	II	7/16	1 17/32	1 17/32	21/64	1/8 + 1/64 — 1/16	2 23/32	3/32 x 3/16	6-32 NC 2	5/16 ± 1/32	3
1010	II	7/16	1 17/32	1 17/32	21/64	1/8 + 1/64 — 1/16	1 1/4	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	1 19/32
1014	I	23/64	1 9/32	1 13/64	17/64	1/8 + 1/32 — 1/64	1	5/64 x 5/32	9/64 DIA.	—	—
1021	II	7/16	2	2	21/64	1/8 + 1/64 — 1/16	2 7/32	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	2 39/64
1022	II	7/16	2	2	21/64	1/8 + 1/64 — 1/16	2 13/16	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	3 3/32
1023	II	9/16	1 3/4	1 3/4	21/64	1/8 + 1/64 — 1/16	2 7/32	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	2 39/64
1028	I	7/16	1 17/32	1 17/32	17/64	1/8 + 1/32 — 1/64	1 1/8	3/32 x 3/16	9/64 DIA.	—	—
1090	II	7/16	1 17/32	1 17/32	21/64	1/8 + 1/64 — 1/16	2 7/32	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	2 39/64
1101	I	19/64	1	1	17/64	1/8 + 1/32 — 1/64	1 1/8	5/64 x 5/32	9/64 DIA.	—	—
1130	II	7/16	2	2	21/64	1/8 + 1/64 — 1/16	1 1/4	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	1 19/32
1200	II	1/2	2 1/2	2 1/2	7/16	1/8 + 1/64 — 1/16	2 1/16	3/32 x 3/16	10-32 NF 2	5/16 MIN.	2 3/8
1214	I	7/16	11/16	11/16	17/64	3/32 ± 1/32	23/32	5/64 x 5/32	9/64 DIA.	—	—
1223	II	1/2	2 1/2	2 1/2	7/16	1/8 + 1/64 — 1/16	2 11/32	3/32 x 3/16	10-32 NF 2	5/16 MIN.	2 21/32
1231	II	13/32	1 5/8	1 5/8	21/64	1/8 + 1/64 — 1/16	2 7/32	3/32 x 3/16	8-32 NC 2	5/16 ± 1/32	2 39/64

FOR ALL MODELS: DIMENSIONS C . . . 5/32, F . . . 1/32, AND K . . . 0.177 DIA.

Fundamental Circuits Using

Federal SELENIUM RECTIFIERS

Federal selenium rectifiers can be utilized in power supplies in virtually the same manner as the vacuum tube diode. For reasons that will be outlined subsequently, many circuits which were previously considered impractical, and hence rarely used, now have new significance and can be employed with great advantage. For example, voltage multiplier circuits which eliminate the need for power transformers in many applications, were practically non-existent in commercial sets heretofore, but have been widely used since the introduction of the selenium rectifier.

The characteristics of the selenium rectifier that have caused this re-evaluation of rectifier circuits are 1) no filament power required, 2) small size, 3) can be installed anywhere under the chassis and 4) larger RMS current capacity relative to its equivalent tube. It boils down to this: The selenium rectifier is as simple and economical to insert into an equipment design as a resistor or a condenser and, therefore, the use of an additional rectifier or two to achieve an improvement in performance is usually justified. This, of course, was not true when tubes were employed.

The well known half-wave rectifier circuit, shown in figure 1, is the simplest and most widely employed. The use of a selenium rectifier, rather than a tube, in this circuit permits the use of a higher capacity filter condenser—since the rectifier has a higher RMS current carrying capacity. By utilizing condensers of larger capacity, better regulation and higher d-c voltages can be obtained. To increase the life of all the components in this circuit, it is recommended that a peak current limiting resistor, which also can be selected to serve as a fuse in case of a short circuit, be inserted in series with the rectifier.

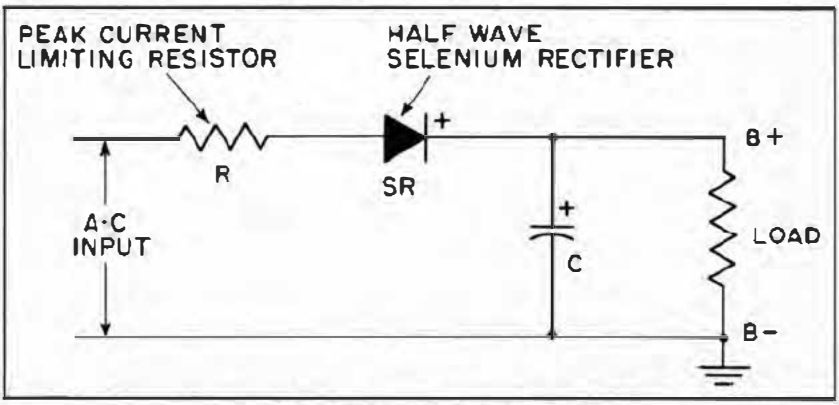


FIG. 1 HALF WAVE RECTIFIER CIRCUIT

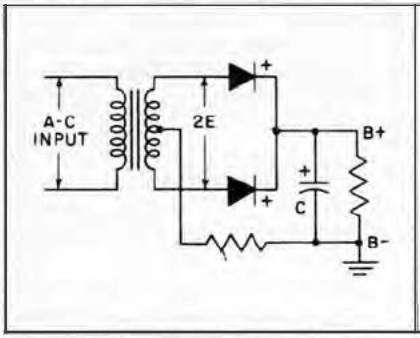


FIG. 2 FULL WAVE CENTER TAP CIRCUIT

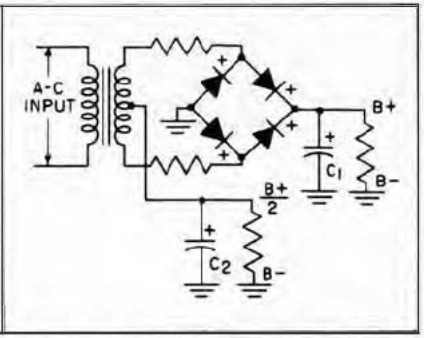


FIG. 3 FULL WAVE BRIDGE CIRCUIT

The half wave circuit, though very simple and economical, is also relatively inefficient and in applications where a higher degree of efficiency is necessary, the full wave center tap circuit shown in figure 2 or the full wave bridge rectifier shown in figure 3 can be employed. The bridge circuit requires four rectifying arms, but makes continuous use of the transformer. The center tap circuit uses only two rectifying arms but only one-half of the transformer secondary is in use during each half cycle. Therefore, the potential from either end of the transformer secondary winding to the center tap must be equal to the full transformer secondary voltage in the bridge circuit, to achieve the same DC output. As a result, with all other factors being equal, the transformer used in the center tap circuit requires a power rating 1.4 times greater than that used in the bridge circuit.

An additional advantage of the bridge circuit is that two voltages may be supplied from the same rectifiers. One is the full B+ voltage obtained from the output terminals of the bridge. The other is equal to one-half the B+ voltage and is obtained by using two arms of the bridge as a full wave center tap circuit (see fig. 3).

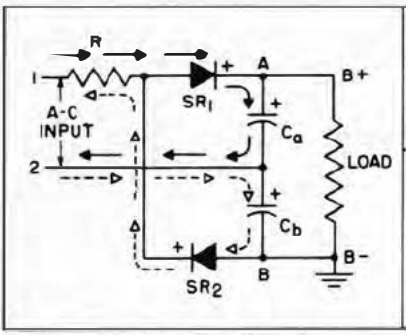


FIG. 4a FULL WAVE VOLTAGE DOUBLER CIRCUIT

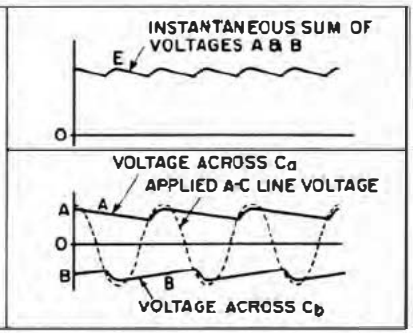


FIG. 4b WAVE FORMS IN THE FULL WAVE DOUBLER CIRCUIT

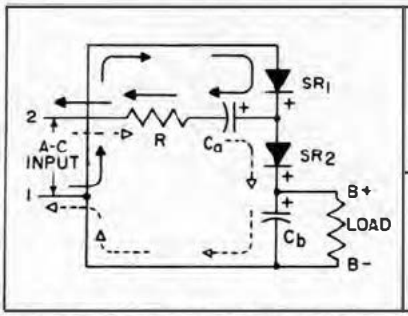


FIG. 5A HALF WAVE VOLTAGE DOUBLER CIRCUIT

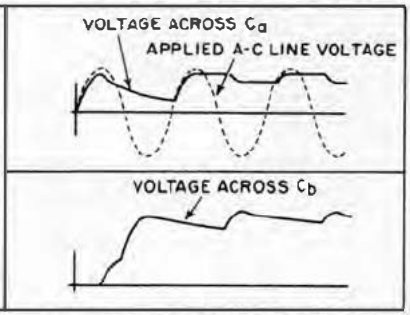


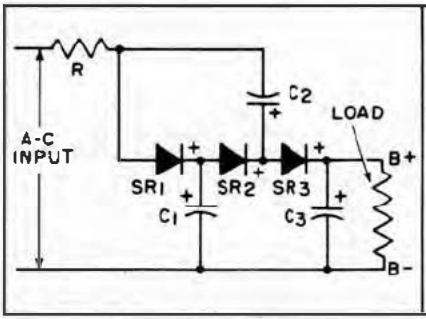
FIG. 5B WAVE FORMS IN THE HALF WAVE DOUBLER CIRCUIT

Voltage Multiplier Circuits

Where potentials exceeding the peak line voltage are desired, voltage multiplier circuits can be utilized to attain this potential without the use of heavy, expensive power transformers. Whereas there is no theoretical limit to the maximum voltage that can be obtained by this means, practical considerations limit their use to approximately three to four times the peak line voltage or about 500 volts for a 117 volt, 60 cycle input.

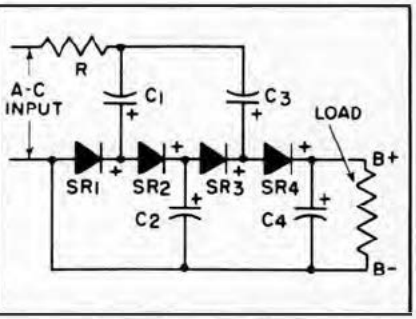
Two types of voltage doubler circuits are shown in figure 4 and 5. The one indicated in figure 4 is known as the full-wave doubler and operates in the following manner: When the line voltage polarity is such that point 1 is at positive potential with respect to point 2, a current will flow, as indicated by the solid arrows, through rectifier SR_1, thus charging condenser C_a so that point A is positive with respect to point 0.* During the next half cycle, when point 2 becomes positive with respect to point 1, SR_2 becomes conductive and condenser C_b charges negatively (as shown by the dotted arrows) with respect to point 0.* The potential difference between points A and B at the end of a full cycle (if the condenser did not discharge) would therefore be twice the peak line voltage. Actually, each condenser discharges during its negative half cycle, so that the cumulative wave-form is as shown in figure 4b.

* Fig. 4B



HALF WAVE VOLTAGE TRIPLER CIRCUIT

FIG. 6



VOLTAGE QUADRUPLER CIRCUIT

The other type of voltage doubler circuit, known as the half-wave doubler, operates on a different principle. Assume that point 1 in figure 5a is positive with respect to point 2 during the initial half cycle. In this case charging current will flow in the direction shown by the solid arrows through rectifier SR_1, until Condenser C_a assumes a charge equal to the peak potential of the line. During the next half cycle, as point 2 becomes positive with respect to point 1, the charge of condenser C_a will add its potential to that of the line and current will flow through rectifier SR_2, as indicated by the dotted arrows, charging condenser C_b to a potential equal to that of the line plus that across condenser C_a. The voltage across C_b therefore is equal to twice the peak line voltage (if condenser C_a does not discharge). Condenser C_b recharges up only during one half of the cycle, and hence the resulting waveform of this circuit will be shown in figure 5b. It should be noted that with all other factors being equal, the half wave circuit provides poorer voltage regulation, and lower ripple frequency, than the full wave doubler.

The principle of the half wave doubler can be extended to higher order voltage multiplier circuits. That is, the voltage across C_b can be added on to a succeeding rectifier condenser circuit to provide triple peak line voltage output, and this latter condenser potential added to another circuit and so on until the desired degree of multiplication is attained. Figure 6 shows the schematic diagram of a voltage tripler and quadrupler circuit.

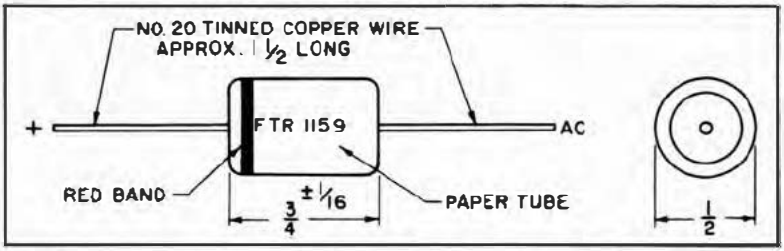
Federal SELENIUM RECTIFIER

FTR MODEL 1159
20 MA, 117 V

ELECTRICAL CHARACTERISTICS

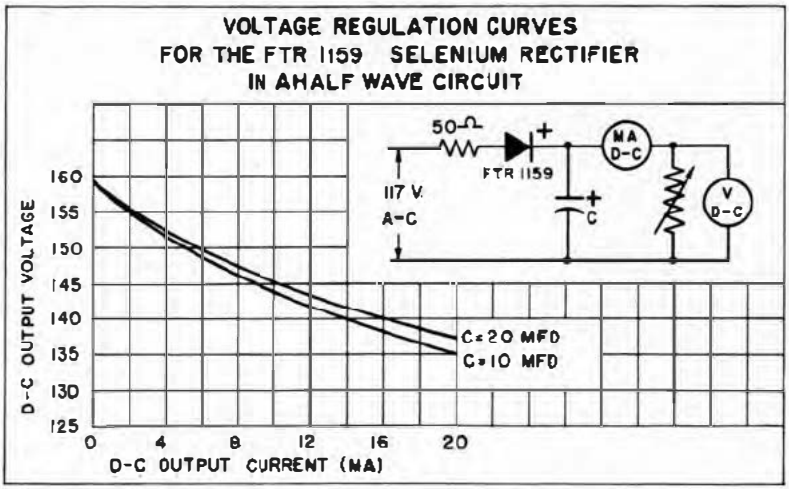
Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	200
Max. RMS Current (Ma)	54
Max. D-C Current (Ma)	20
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	50
Max. Cell Operating Temperature (°C)	85

DIMENSIONAL DIAGRAM



CIRCUIT APPLICATION

The Federal 1159 selenium rectifier is used in equipment requiring a small amount of B+ power, such as phonographs, oscillators, or TV boosters, and in bias supplies of larger sets where the separation of bias and B+ is desirable. The characteristic curves for this rectifier in a half-wave circuit are shown below.



Federal SELENIUM RECTIFIER

FTR MODEL 1214

50 MA, 117 V

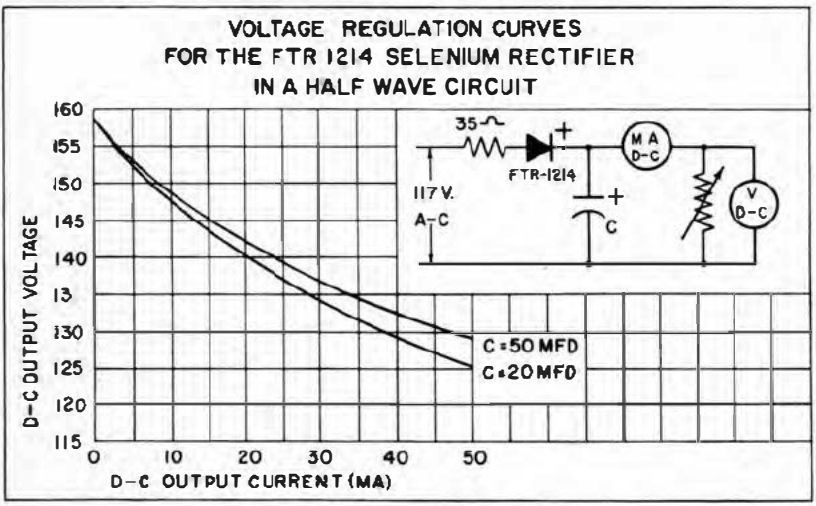
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	500
Max. RMS Current (Ma)	135
Max. D-C Current Output (Ma)	50
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	35
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1214 selenium rectifier is used mainly in one tube sets, such as phonograph oscillators or UHF converters, or in bias supplies of larger sets where separation of bias and B+ supplies is desirable. The characteristic curves for this rectifier in a half-wave circuit is given below.



Federal SELENIUM RECTIFIER

FTR MODEL 1002

65 MA, 117 V

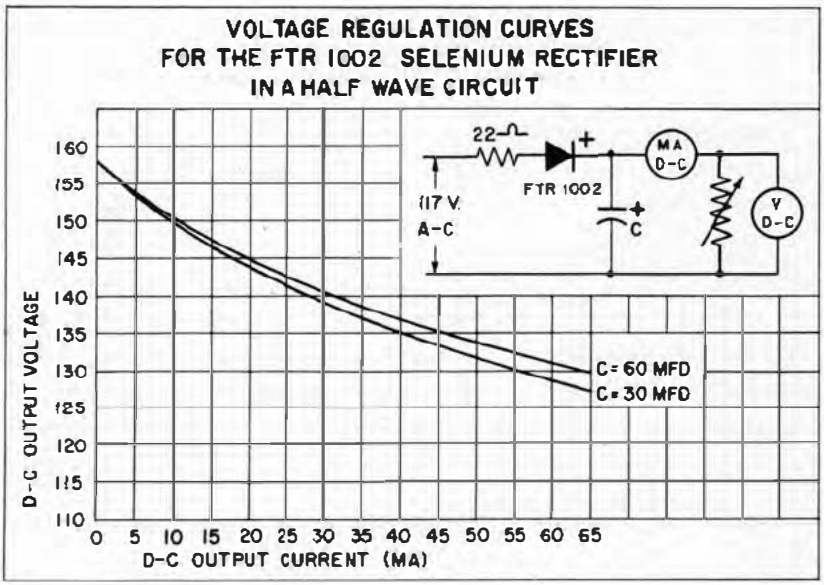
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	650
Max. RMS Current (Ma)	175
Max. D-C Current Output (Ma)	65
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

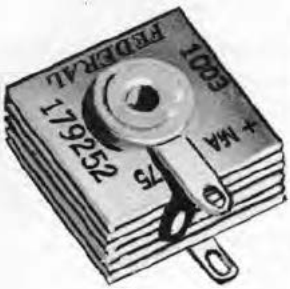
The Federal 1002 selenium rectifier is used in small a-c/d-c and three way portable AM receivers. Since the selenium rectifier operates instantly —no warm up period required—three-way portables play as soon as they are turned on in the a-c/d-c position as well as in the battery position if all tubes use directly heated cathodes.



Federal SELENIUM RECTIFIER

FTR MODEL 1003

75 MA, 117 V



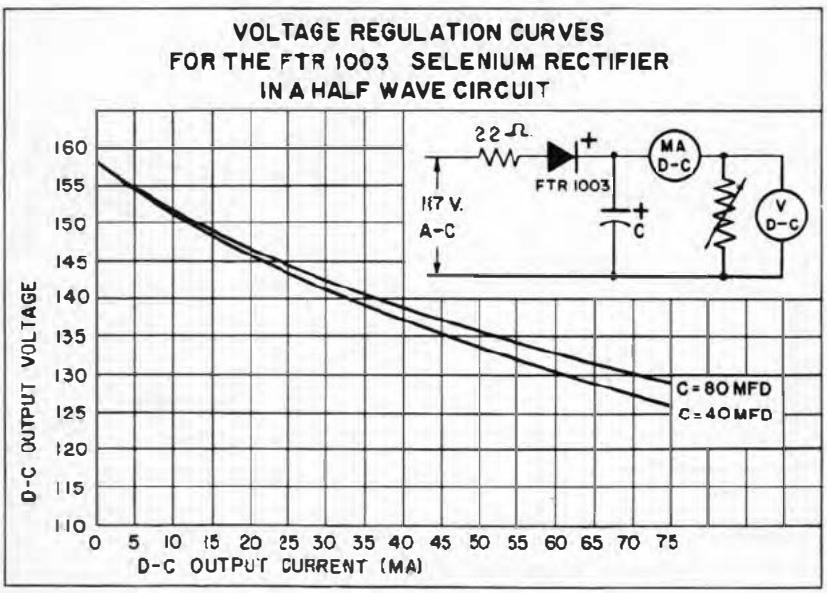
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	750
Max. RMS Current (Ma)	200
Max. D-C Current Output (Ma)	75
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1003 selenium rectifier is used in many four-tube (plus rectifier) a-c/d-c and three-way portable AM or FM receivers. Since the selenium rectifier operates instantly—no warm-up period required—three-way portables play as soon as they are turned on in the a-c/d-c position as well as in the battery position if all tubes use directly heated cathodes.



Federal SELENIUM RECTIFIER

FTR MODEL 1004

100 MA, 117 V

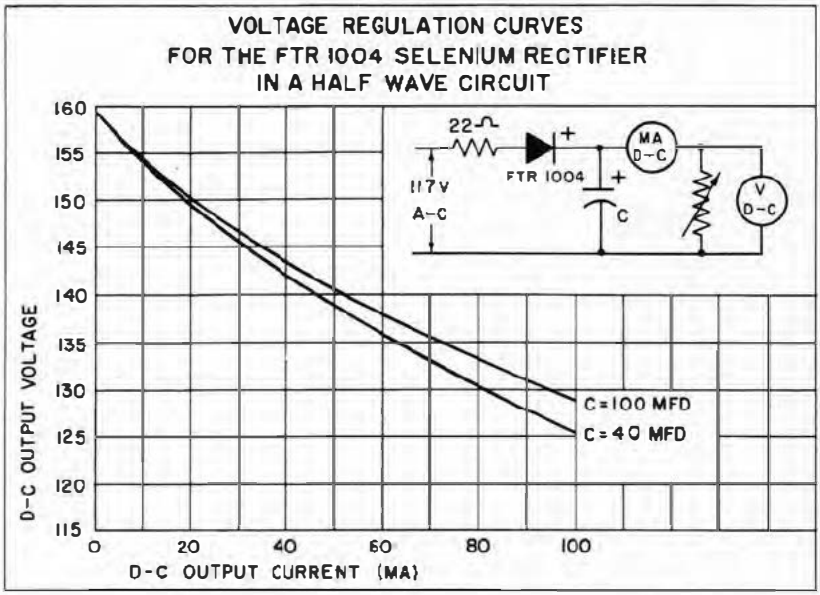
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	1000
Max. RMS Current (Ma)	270
Max. D-C Current Output (Ma)	100
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1004 selenium rectifier is used in many four-tube (plus rectifier) a-c/d-c and three-way portable AM or FM receivers. Since the selenium rectifier operates instantly—no warm-up period required—three-way portables play as soon as they are turned on in the a-c/d-c position as well as in the battery position if all tubes use directly heated cathodes.



Federal SELENIUM RECTIFIER

FTR MODEL 1101

100 MA, 117 V

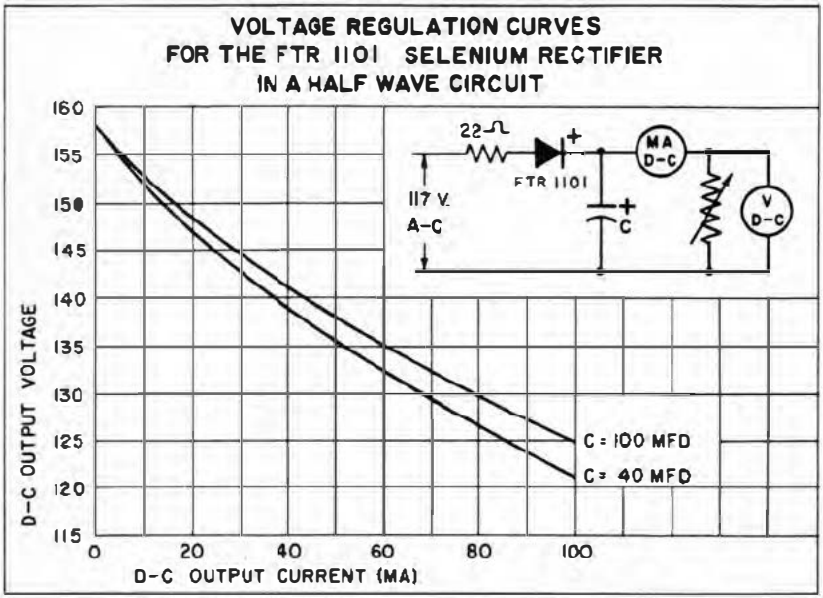
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	1000
Max. RMS Current (Ma)	270
Max. D-C Current Output (Ma)	100
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1101 selenium rectifier is used in many four-tube (plus rectifier) a-c/d-c and three-way portable AM or FM receivers. Since the selenium rectifier operates instantly—no warm-up period required—three-way portables play as soon as they are turned on in the a-c/d-c position as well as in the battery position if all tubes use directly heated cathodes.



Federal SELENIUM RECTIFIER

FTR MODEL 1005

150 MA, 117 V

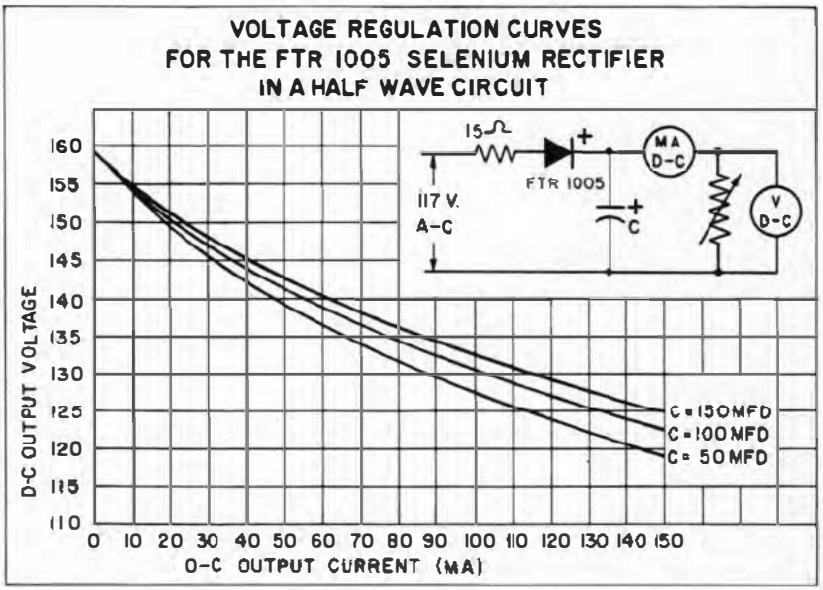
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	1500
Max. RMS Current (Ma)	410
Max. D-C Current Output (Ma)	150
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	15
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

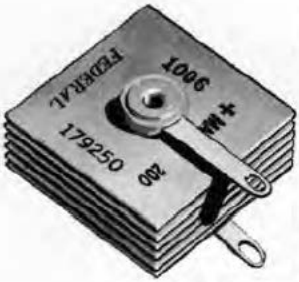
The Federal 1005 selenium rectifier is used in all types of combination radio-phonograph sets, small television sets, and other electronic equipment requiring d-c load currents up to 150 ma. The characteristic curves for this rectifier are shown below.



Federal SELENIUM RECTIFIER

FTR MODEL 1006

200 MA, 117 V



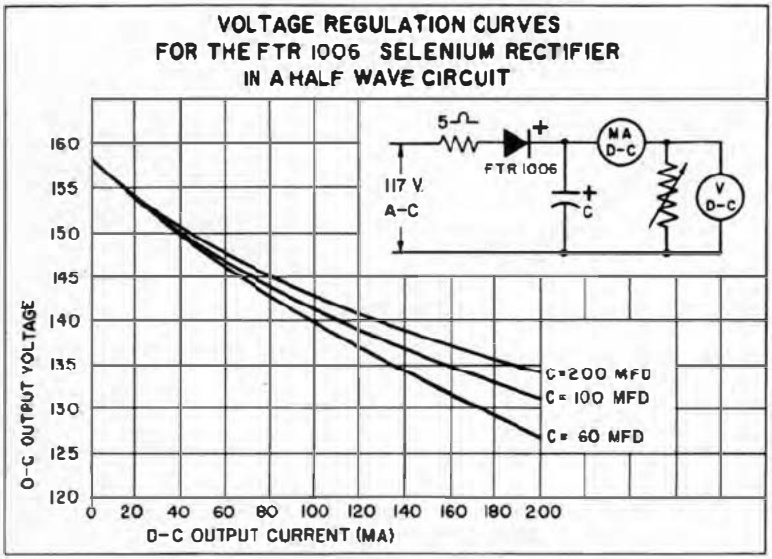
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	2000
Max. RMS Current (Ma)	540
Max. D-C Current Output (Ma)	200
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1006 selenium rectifier has been widely used in small screen television sets to provide all necessary B+ voltage without use of the bulky and relatively costly power transformer. It is also used in combination radio-phonograph sets and in other electronic equipment requiring d-c loads up to 200 ma. Characteristic curves for this rectifier in half-wave and voltage doubler circuits are given below and on next page.

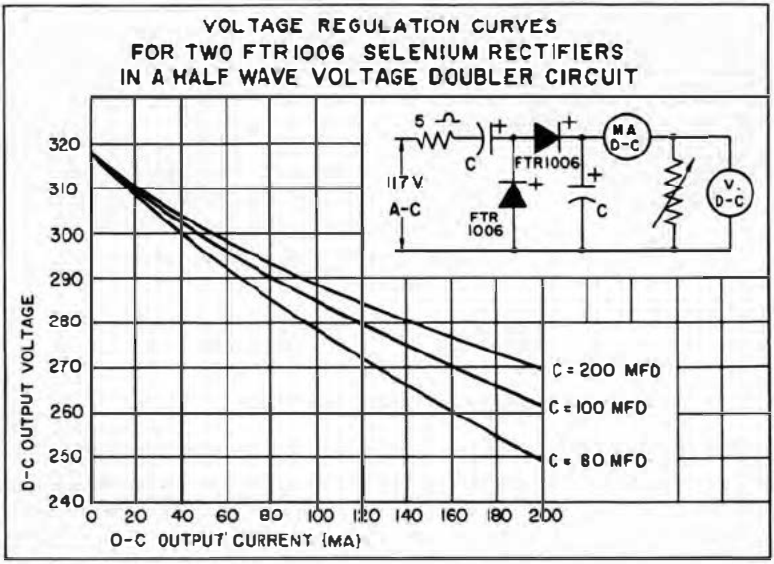


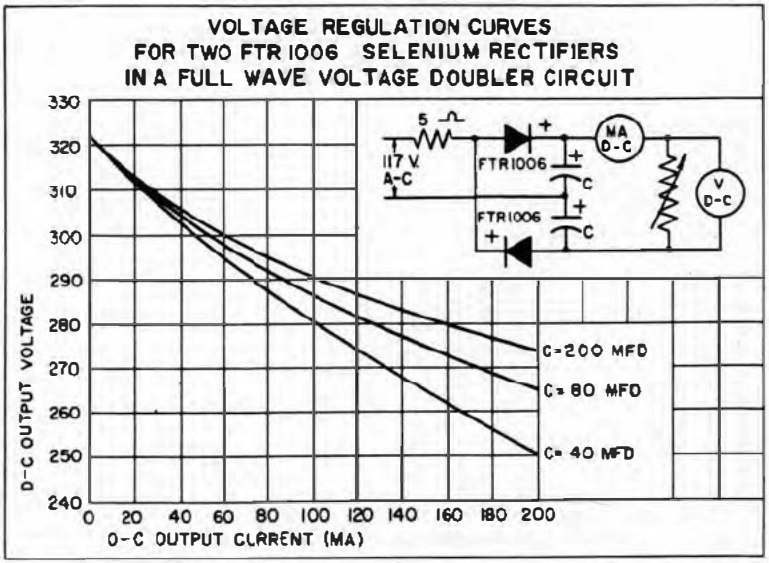
Federal SELENIUM RECTIFIER

FTR MODEL 1006

200 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

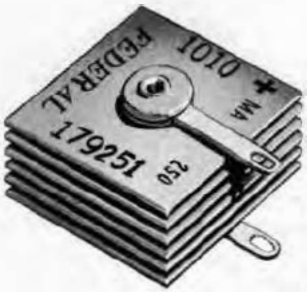




Federal SELENIUM RECTIFIERS

FTR MODELS 1010 and 1028

250 MA, 117 V



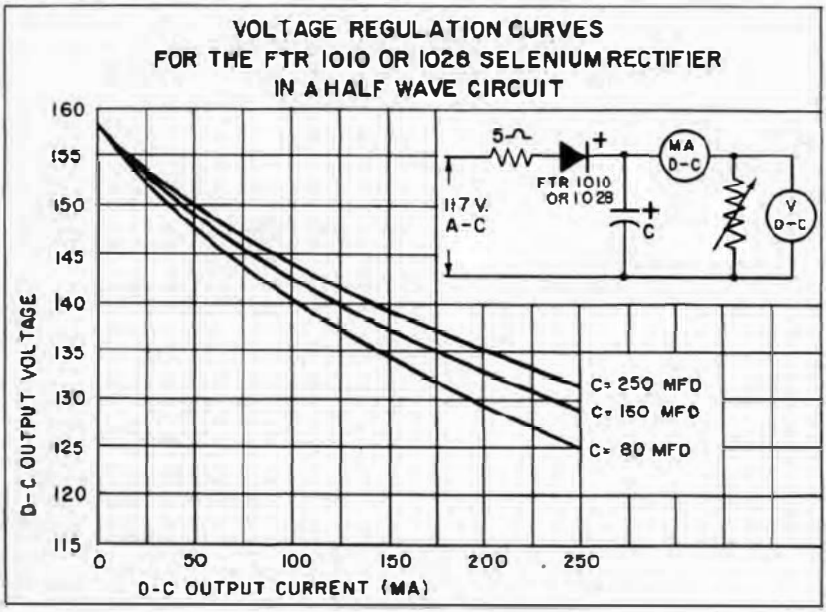
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	2500
Max. RMS Current (Ma)	675
Max. D-C Current Output (Ma)	250
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1010 and 1028 selenium rectifiers are similar electrically but differ in mechanical construction in that the 1010 is available only in the stud construction while 1028 is available in eyelet construction. Both rectifiers are used in television sets, combination radio-phonographs, and other electronic equipment requiring d-c loads up to 250 ma. Characteristic curves for this rectifier in half-wave, voltage doubler and tripler circuits are given below and on next page.

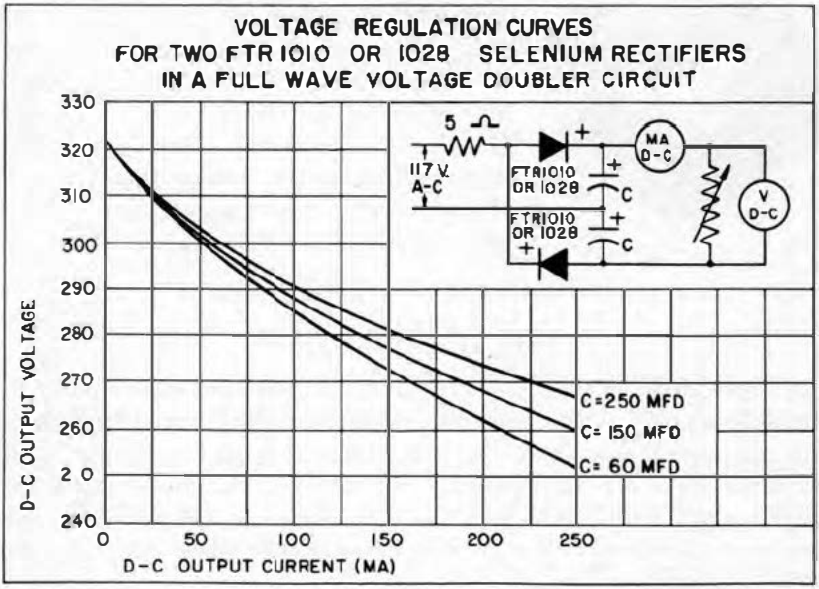


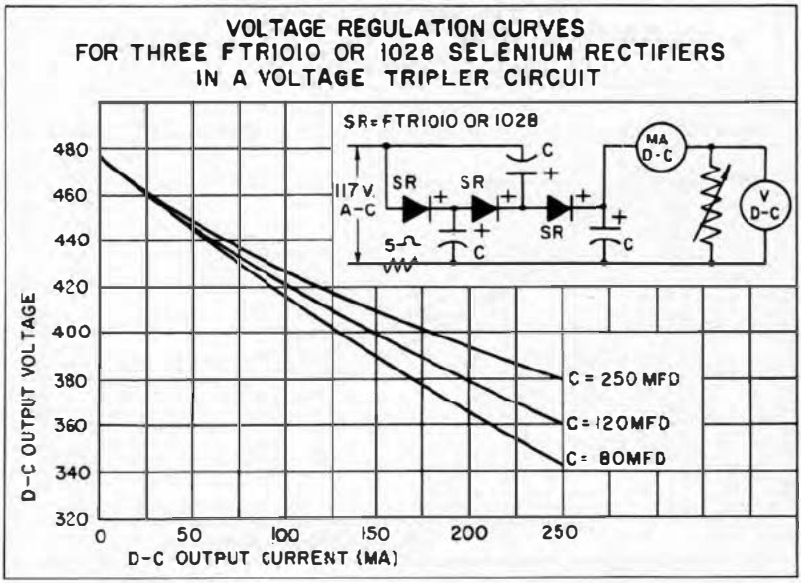
Federal SELENIUM RECTIFIERS

FTR MODELS 1010 and 1028

250 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

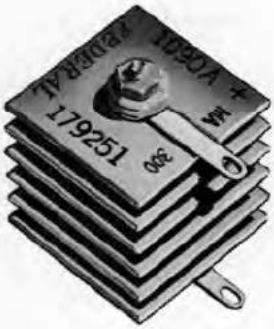




Federal SELENIUM RECTIFIER

FTR MODEL 1090

300 MA. 117 V



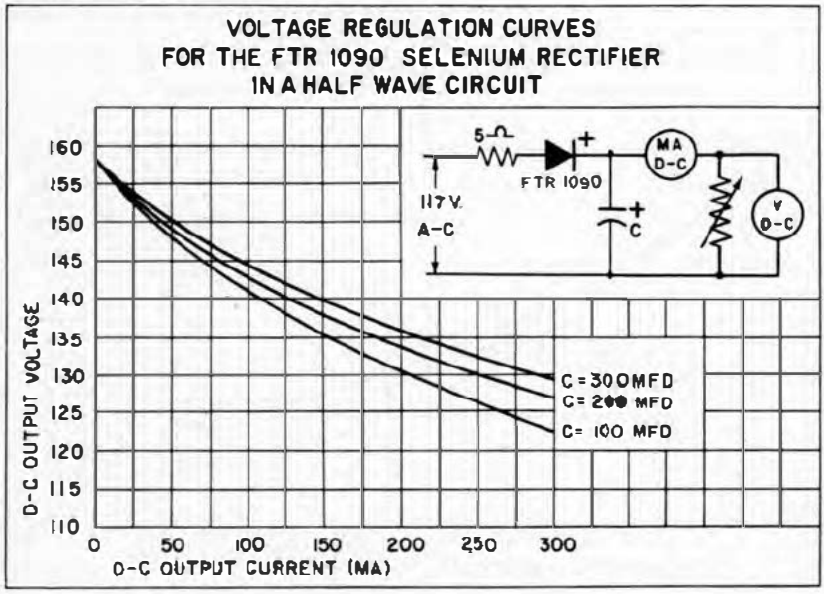
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	3000
Max. RMS Current (Ma)	810
Max. D-C Current Output (Ma)	300
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1090 selenium rectifier is used primarily in television and combination sets. The high current rating of this rectifier makes it possible to simplify the design of television receivers. Heretofore, because high current rectifier tubes are bulky and expensive, high B+ voltages were required to attain necessary power with lower current. However, with Federal's rectifiers it is possible to power these sets at the same B+ voltages used in AM and FM sets. Characteristic curves are shown below and on next page.

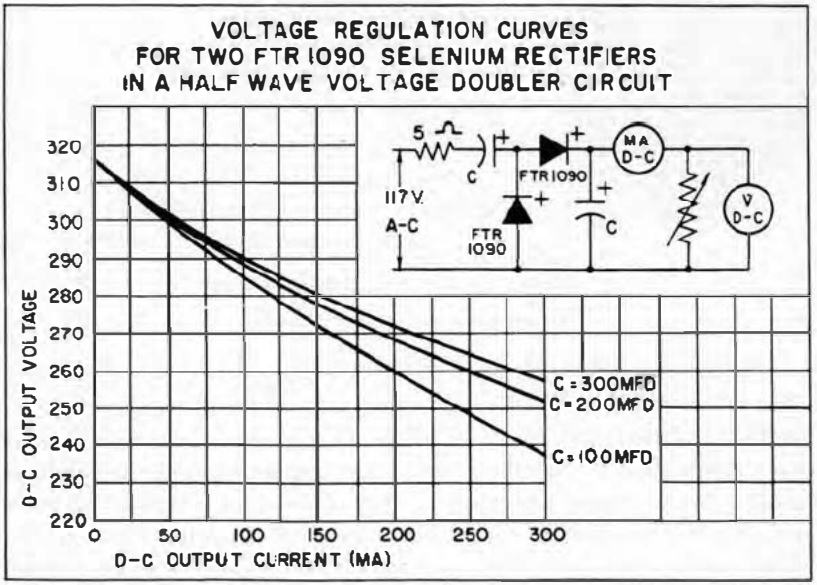


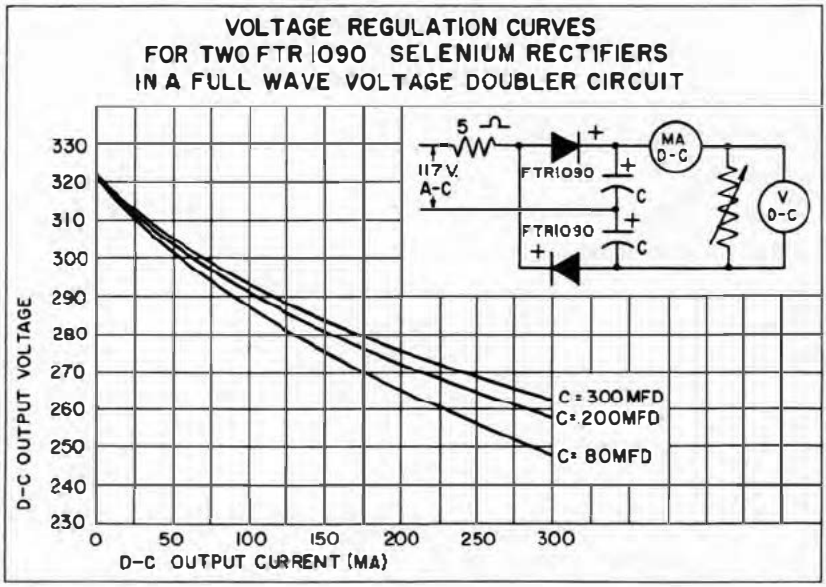
Federal SELENIUM RECTIFIER

FTR MODEL 1090

300 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

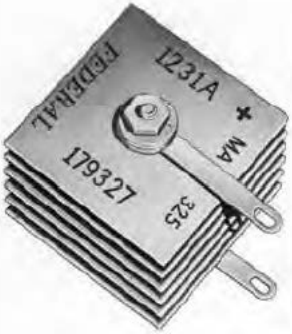




Federal SELENIUM RECTIFIER

FTR MODEL 1231

325 MA, 117 V



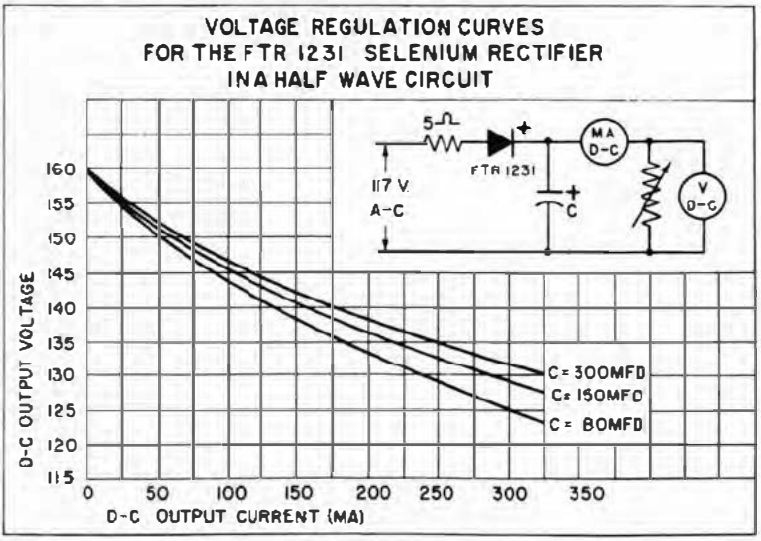
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	3250
Max. RMS Current (Ma)	880
Max. D-C Current Output (Ma)	325
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1231 selenium rectifier is used primarily in television and combination sets. The high current rating of this rectifier makes it possible to simplify the design of television receivers. Heretofore, because high current rectifier tubes are bulky and expensive, high B+ voltages were required to attain necessary power with lower current. However, with Federal's rectifiers it is possible to power these sets at the same B+ voltages used in AM and FM sets. Characteristic curves are shown below and on next page.

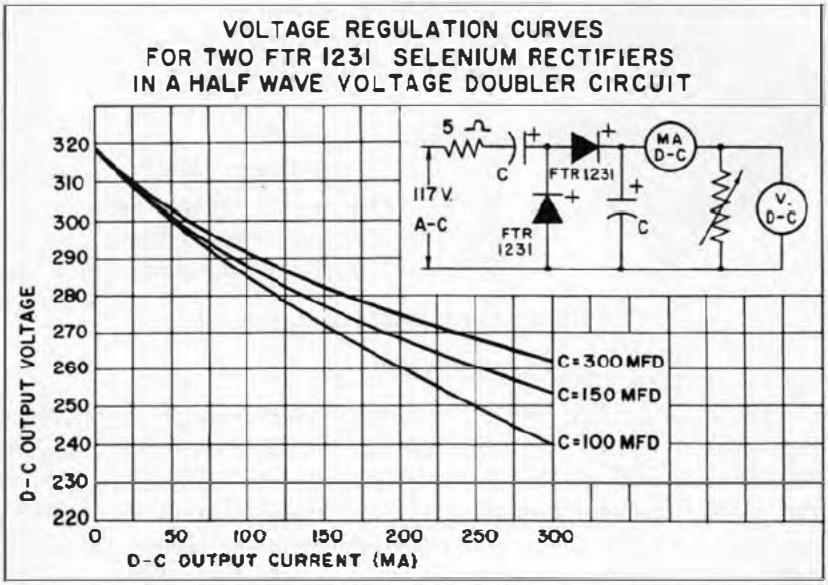


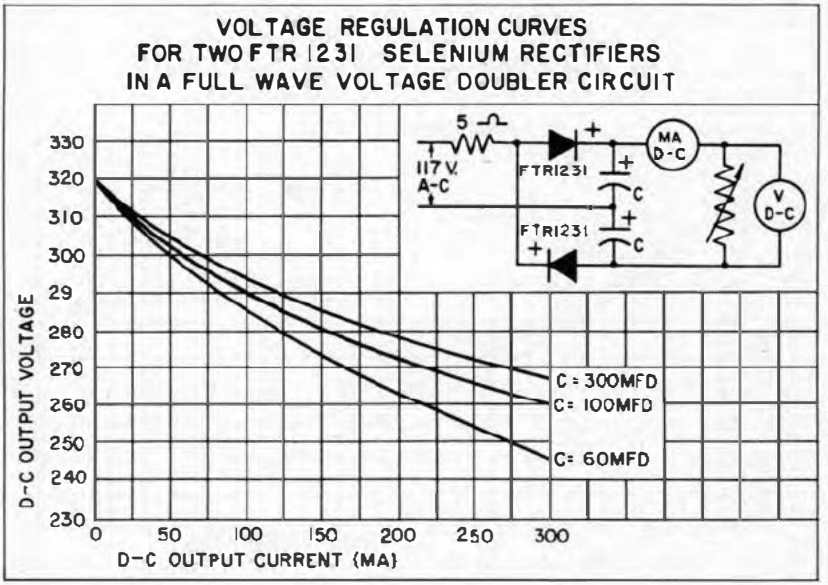
Federal SELENIUM RECTIFIER

FTR MODEL 1231

325 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

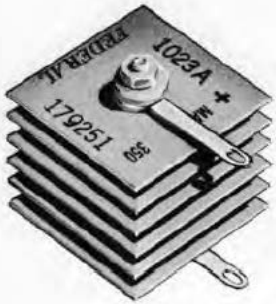




Federal SELENIUM RECTIFIER

FTR MODEL 1023

350 MA, 117 V



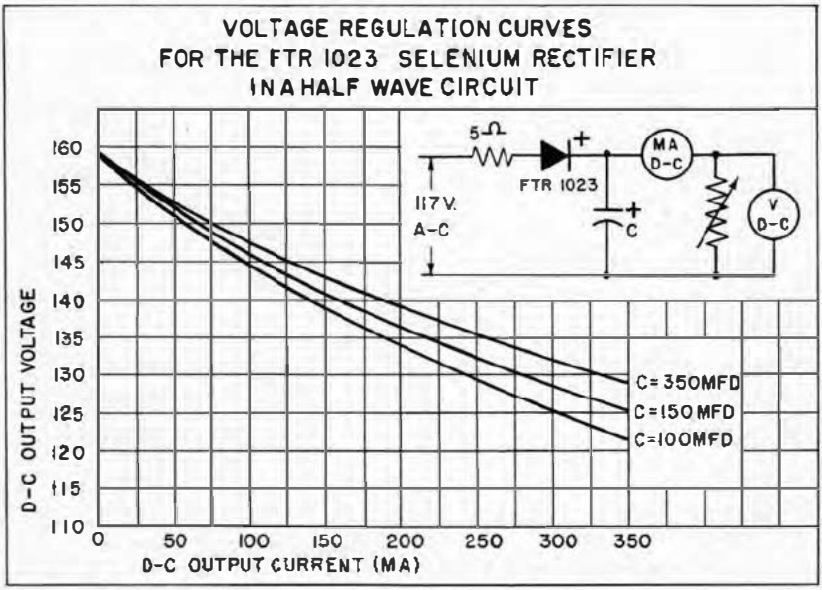
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	3500
Max. RMS Current (Ma)	945
Max. D-C Current Output (Ma)	350
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1023 selenium rectifier is used primarily in television and combination sets. The high current rating of this rectifier makes it possible to simplify the design of television receivers. Heretofore, because high current rectifier tubes are bulky and expensive, high B+ voltages were required to attain necessary power with lower current. However, with Federal's rectifiers it is possible to power these sets at the same B+ voltages used in AM and FM sets. Characteristic curves are shown below and on next page.

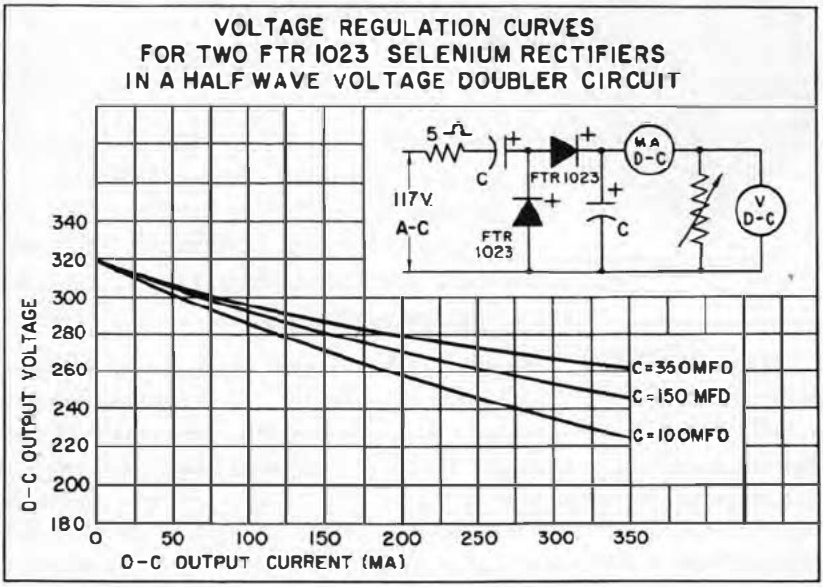


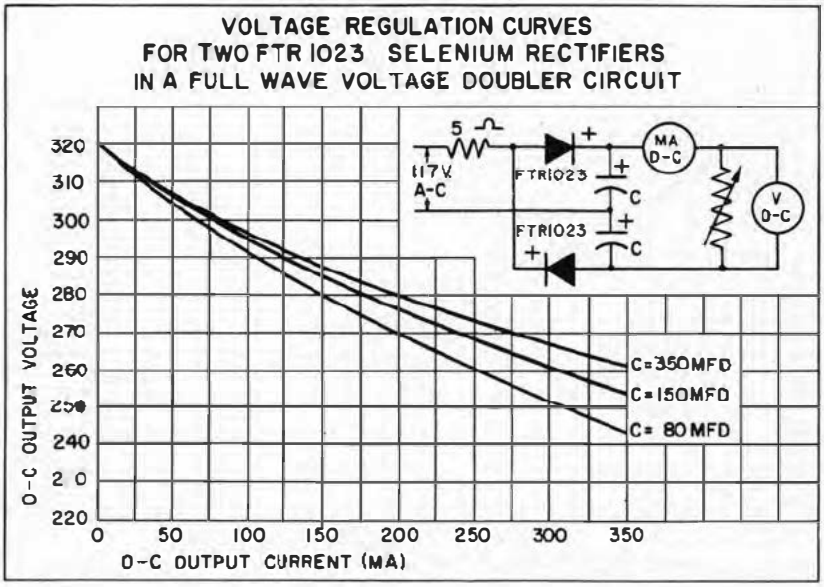
Federal SELENIUM RECTIFIER

FTR MODEL 1023

350 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

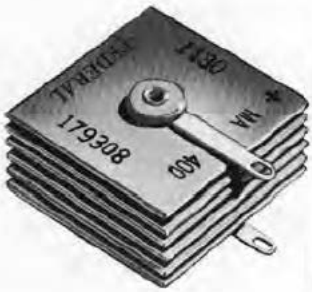




Federal SELENIUM RECTIFIER

FTR MODEL 1130

400 MA, 117 V



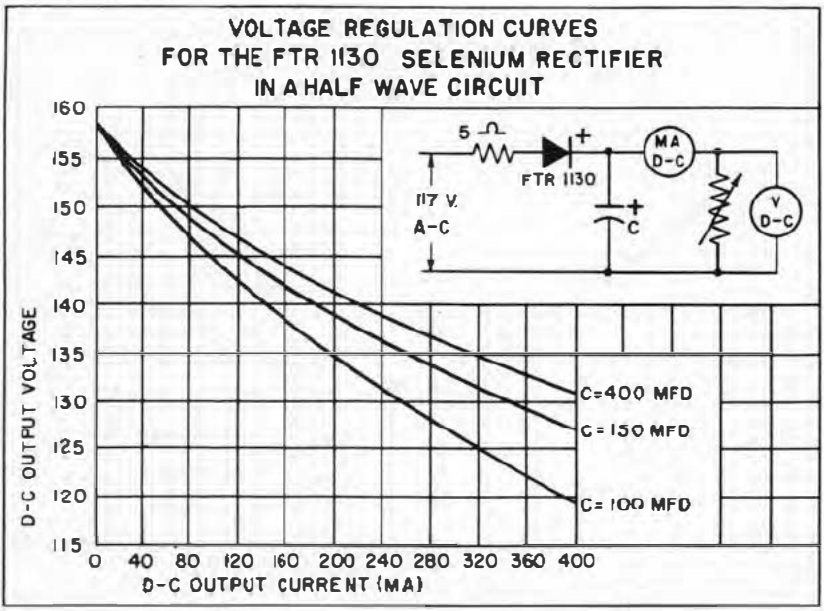
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	4000
Max. RMS Current (Ma)	1080
Max. D-C Current Output (Ma)	400
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1130 selenium rectifier is used primarily in television and combination sets. The high current rating of this rectifier makes it possible to simplify the design of television receivers. Heretofore, because high current rectifier tubes are bulky and expensive, high B+ voltages were required to attain necessary power with lower current. However, with Federal's rectifiers it is possible to power these sets at the same B+ voltages used in AM and FM sets. Characteristic curves are shown below and on next page.

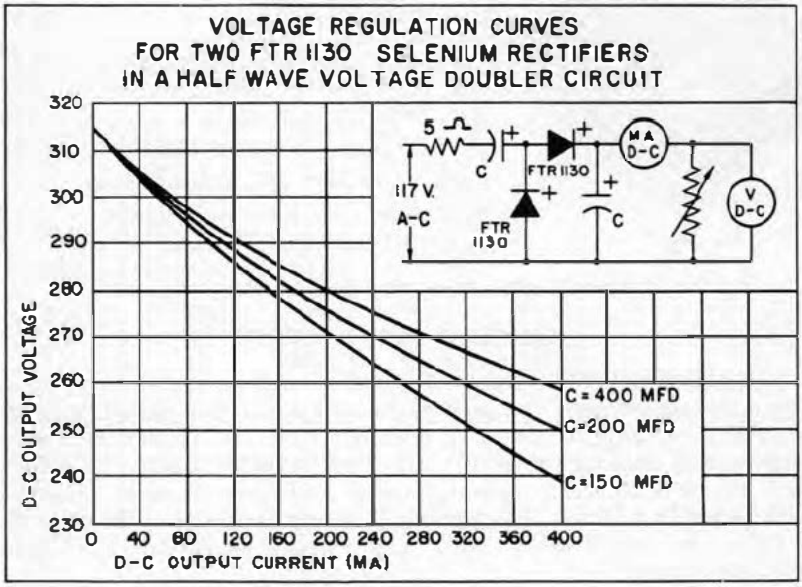


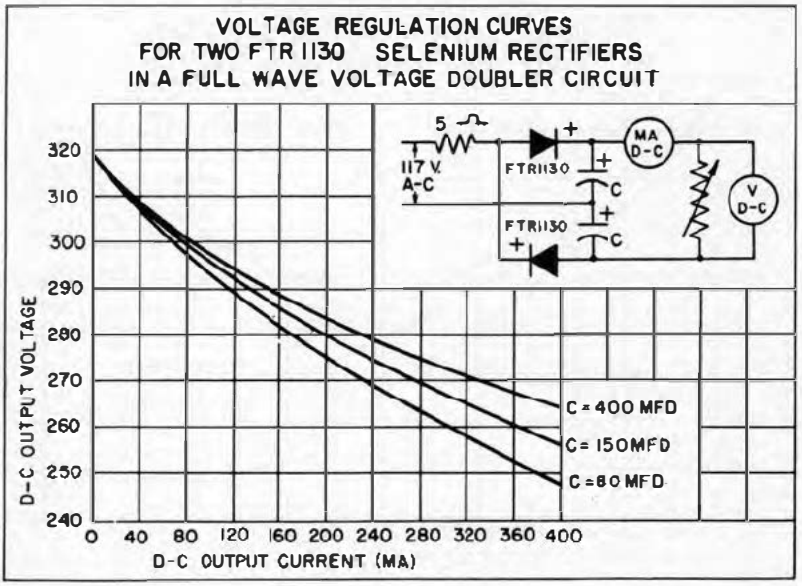
Federal SELENIUM RECTIFIER

FTR MODEL 1130

400 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

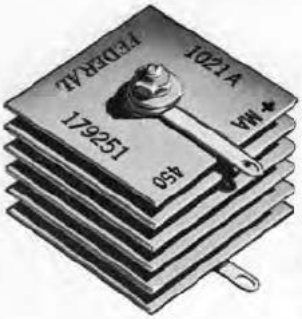




Federal SELENIUM RECTIFIER

FTR MODEL 1021

450 MA, 117 V



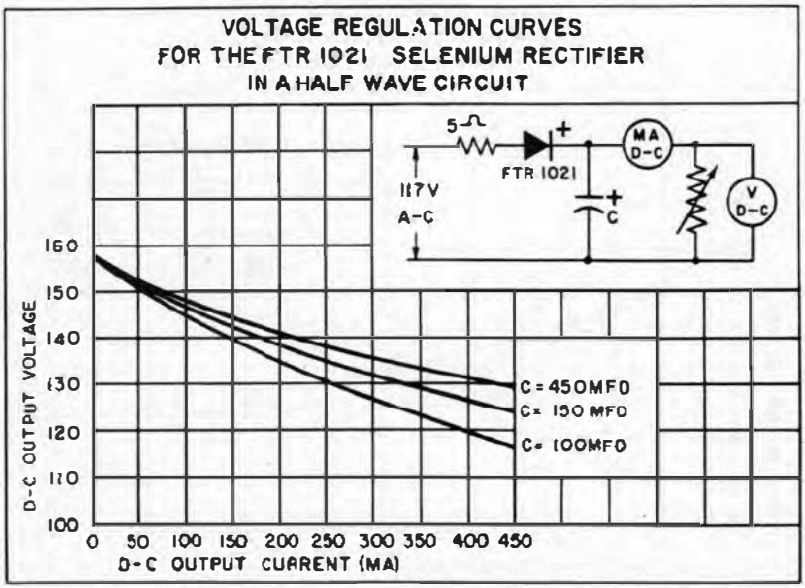
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	4500
Max. RMS Current (Ma)	1200
Max. D-C Current Output (Ma)	450
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1021 selenium rectifier is used primarily in television and combination sets. The high current rating of this rectifier makes it possible to simplify the design of television receivers. Heretofore, because high current rectifier tubes are bulky and expensive, high B+ voltages were required to attain necessary power with lower current. However, with Federal's rectifiers it is possible to power these sets at the same B+ voltages used in AM and FM sets. Characteristic curves are shown below and on next page.



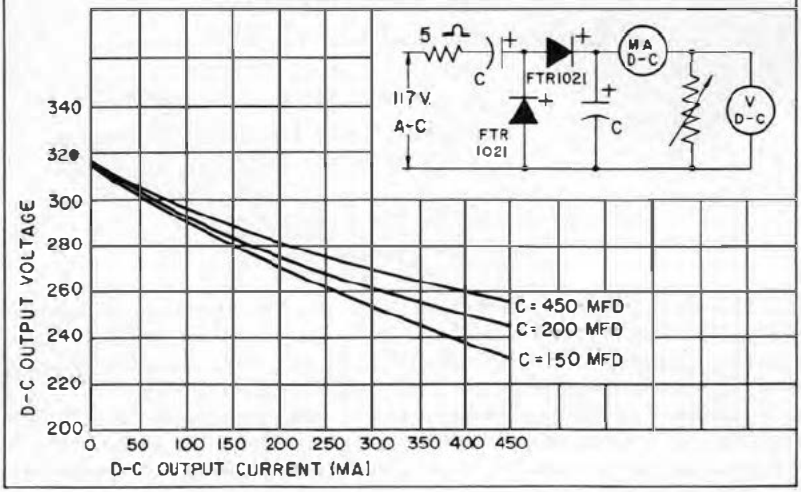
Federal SELENIUM RECTIFIER

FTR MODEL 1021

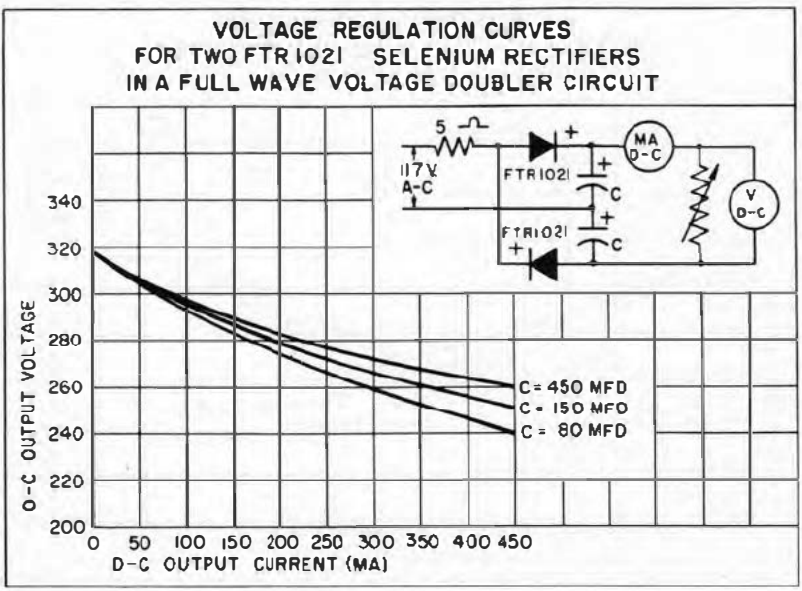
450 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

VOLTAGE REGULATION CURVES
FOR TWO FTR 1021 SELENIUM RECTIFIERS
IN A HALF WAVE VOLTAGE DOUBLER CIRCUIT



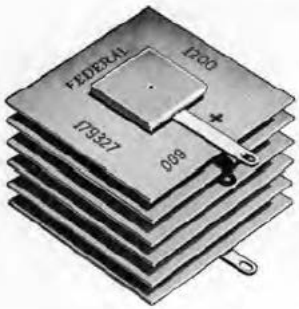
VOLTAGE REGULATION CURVES
FOR TWO FTR 1021 SELENIUM RECTIFIERS
IN A FULL WAVE VOLTAGE DOUBLER CIRCUIT



Federal SELENIUM RECTIFIER

FTR MODEL 1200

600 MA, 117 V



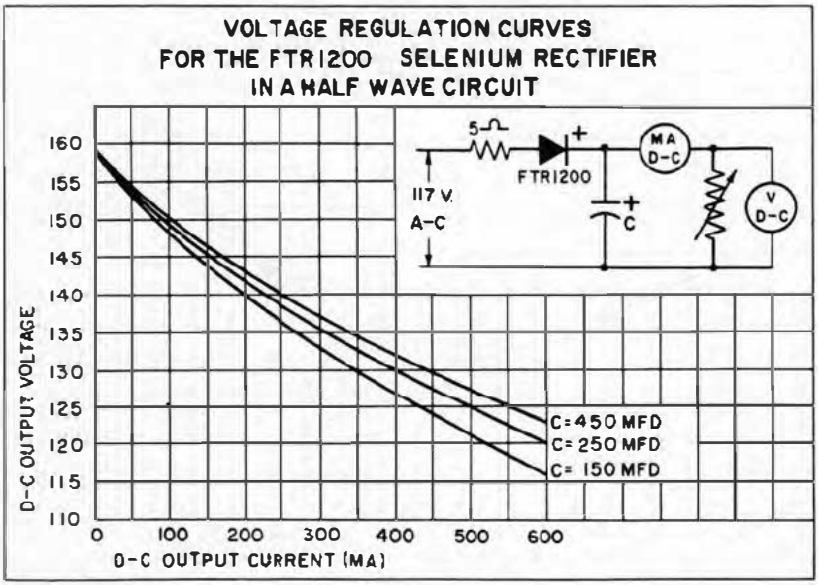
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	6000
Max. RMS Current (Ma)	1600
Max. D-C Current (Ma)	600
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1200 selenium rectifier is used for combination radio-television-phonograph console models and color television sets. The characteristic curves for this rectifier are shown below and on the following page.

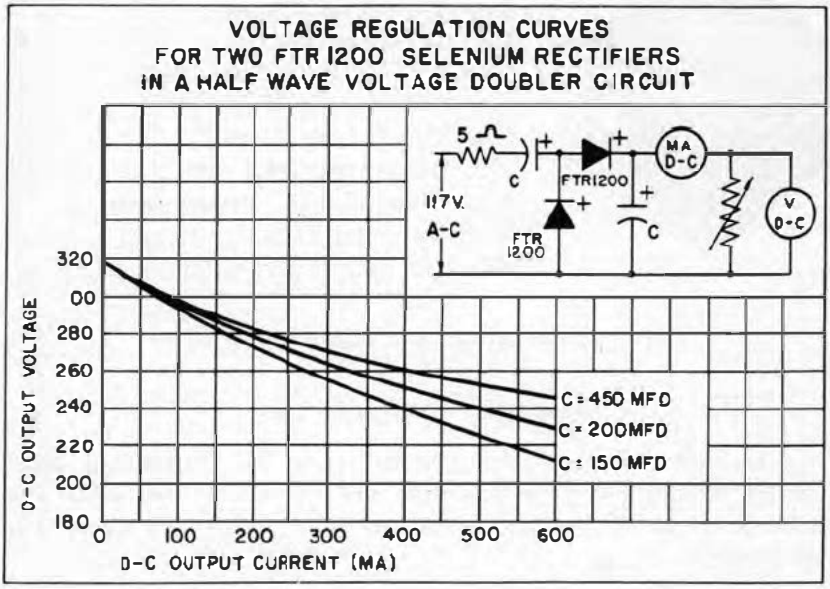


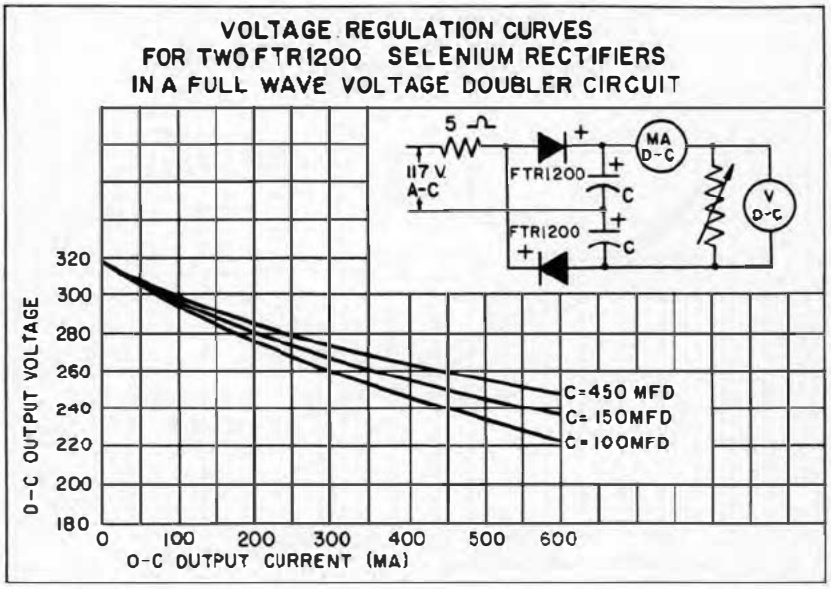
Federal SELENIUM RECTIFIER

FTR MODEL 1200

600 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

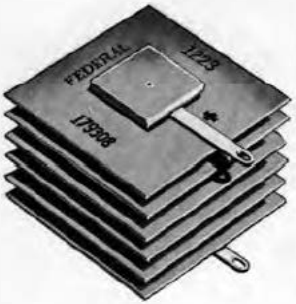




Federal SELENIUM RECTIFIER

FTR MODEL 1223

750 MA, 117 V



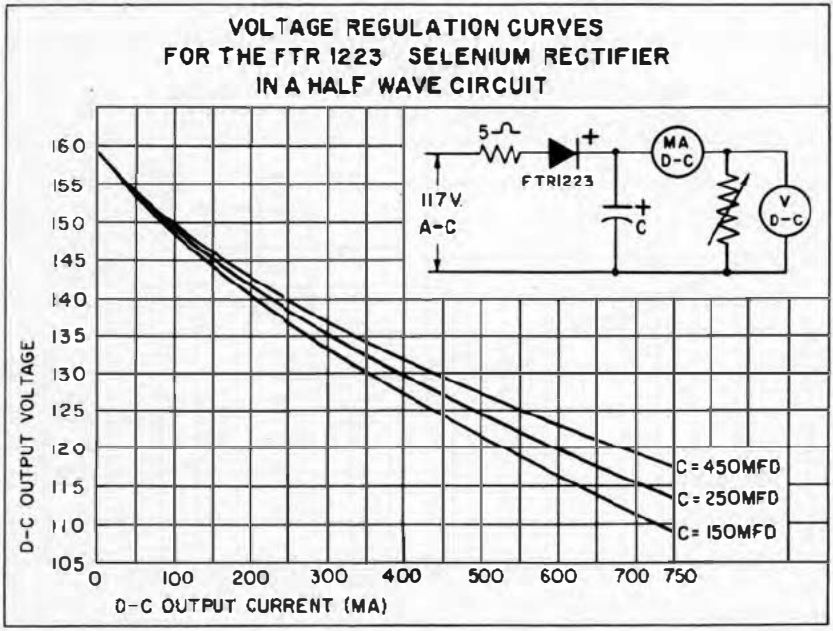
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	117
Max. RMS Input Voltage	130
Max. Peak Inverse Voltage	380
Max. Peak Current (Ma)	7500
Max. RMS Current (Ma)	2000
Max. D-C Current (Ma)	750
Approx. Rectifier D-C Voltage Drop	7
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1223 selenium rectifier is used for combination radio-television-phonograph console models and color television sets. The characteristic curves for this rectifier are given below and on the following pages.

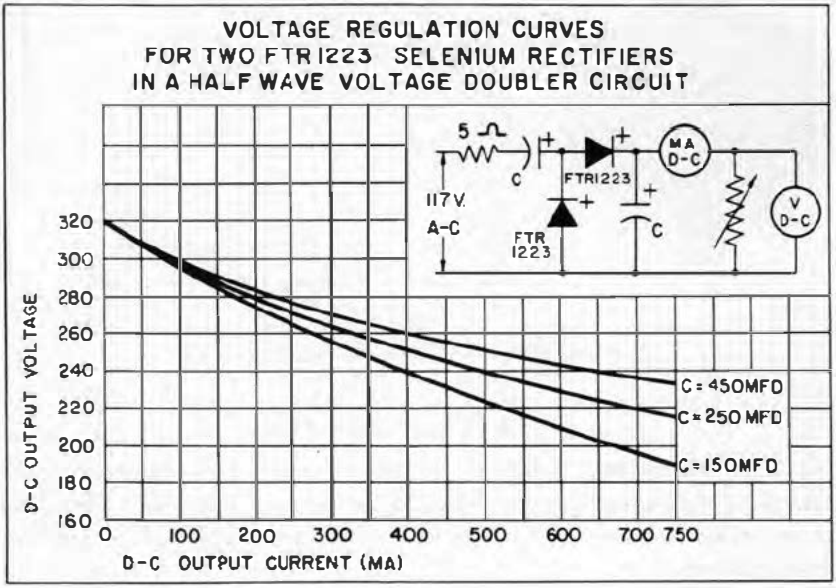


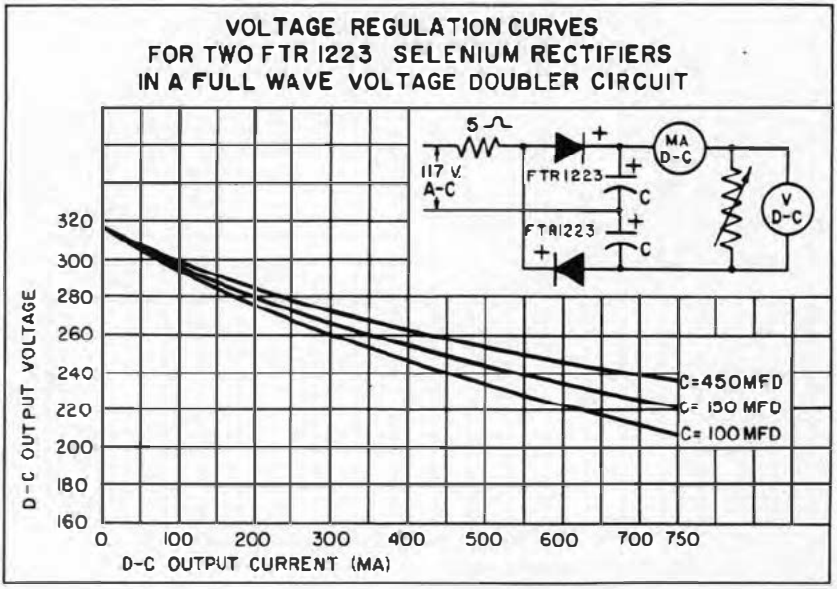
Federal SELENIUM RECTIFIER

FTR MODEL 1223

750 MA, 117 V

CHARACTERISTIC CURVES *(Continued)*

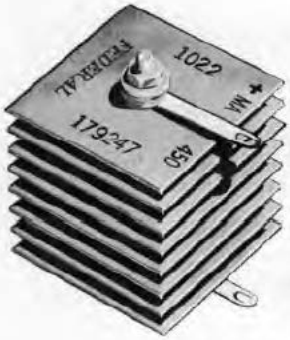




Federal SELENIUM RECTIFIER

FTR MODEL 1022

450 MA, 150 V



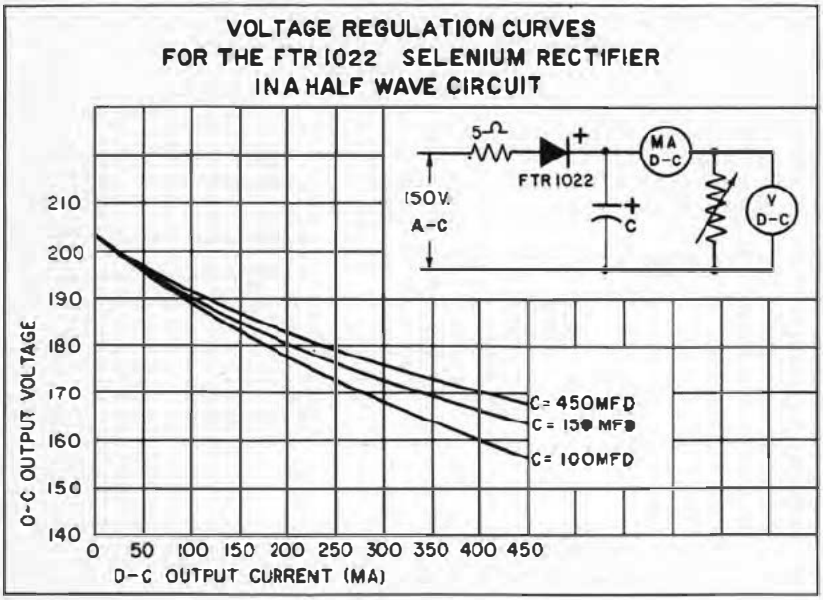
ELECTRICAL CHARACTERISTICS

Rated RMS Input Voltage	150
Max. RMS Input Voltage	160
Max. Peak Inverse Voltage	460
Max. Peak Current (Ma)	4500
Max. RMS Current (Ma)	1200
Max. D-C Current (Ma)	450
Approx. Rectifier D-C Voltage Drop	9
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1022 selenium rectifier is designed for use in larger television receivers and AM-FM-phonograph combination consoles. It also can be used with an auto-transformer or an isolation transformer having a slight step-up with two voltage doubler circuits arranged in series for powering projection television sets where a 500-volt, 400 ma supply is required. The FTR Model 1022 rectifier can also be used in any type of high power audio system in half-wave or voltage multiplier circuits. The characteristic curves for this rectifier is shown below and on the following page.

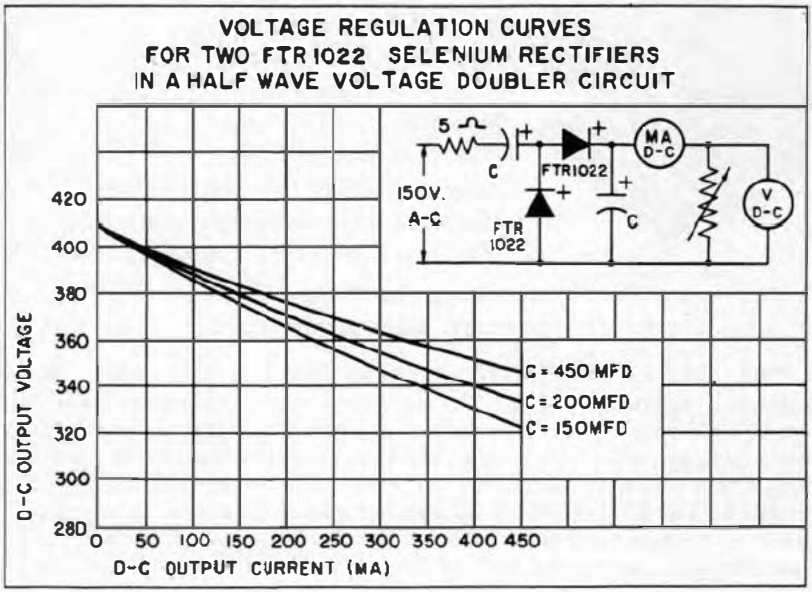


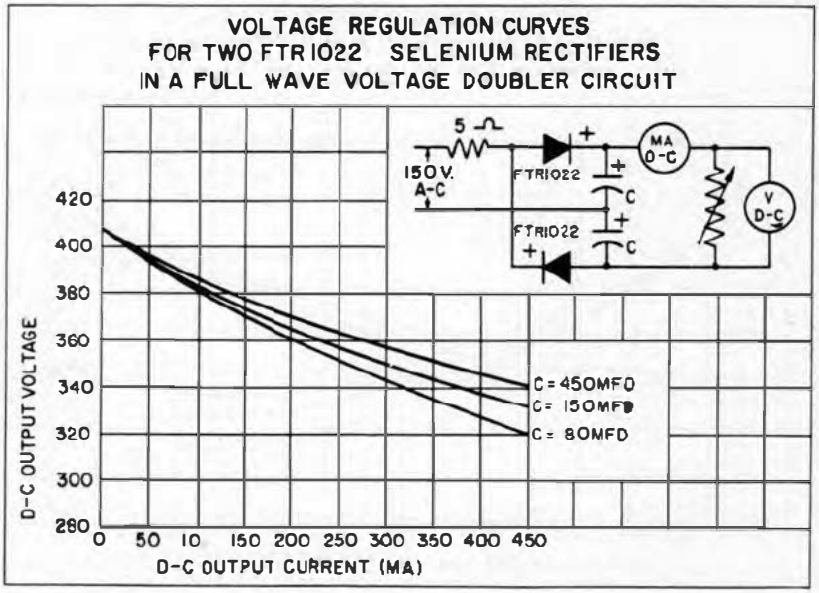
Federal SELENIUM RECTIFIER

FTR MODEL 1022

450 MA, 150 V

CHARACTERISTIC CURVES *(Continued)*

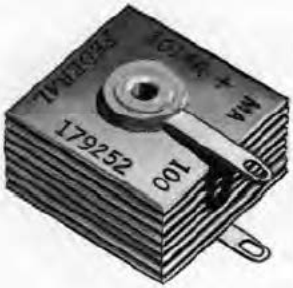




Federal SELENIUM RECTIFIER

FTR MODEL 1014

100 MA, 150 V



ELECTRICAL CHARACTERISTICS

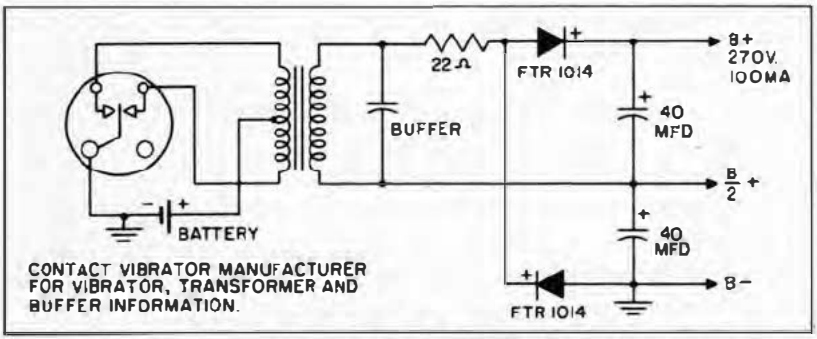
Rated RMS Input Voltage	150
Max. RMS Input Voltage	160
Max. Peak Inverse Voltage	460
Max. Peak Current (Ma)	1000
Max. RMS Current (Ma)	270
Max. D-C Current Output (Ma)	100
Approx. Rectifier D-C Voltage Drop	9
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1014 selenium rectifier is one of a series of rectifiers (the others to be described in subsequent pages) developed for use in vibrator power supplies. Selenium rectifier vibrator supplies, due to the low voltage drop across the rectifier and the fact that no filaments are required, are up to 40% more efficient in appropriate circuits than dynamotor or rectifier tube supplies providing the same output. This is a very important factor, particularly in mobile radio and television applications, since this efficiency is reflected in less battery current drain.

To attain maximum efficiency, the full wave doubler circuit, shown below, is usually used in these vibrator supplies. For this reason, most of the rectifier types developed for this application are manufactured with two rectifiers assembled together—to eliminate two assembly line operations for the equipment manufacturer. An exception to this is the FTR 1014 rectifier, which is a single unit, manufactured in this way so that the rectifiers may he placed side by side in the chassis rather than lengthwise. The characteristic curves for this rectifier are the same as shown on page 45 for FTR Model 1008 rectifier—the latter being similar electrically to two 1014's assembled together.



TYPICAL FULL WAVE DOUBLER VIBRATOR POWER SUPPLY

Federal SELENIUM RECTIFIER

FTR MODEL 1007

75 MA, DOUBLER

ELECTRICAL CHARACTERISTICS

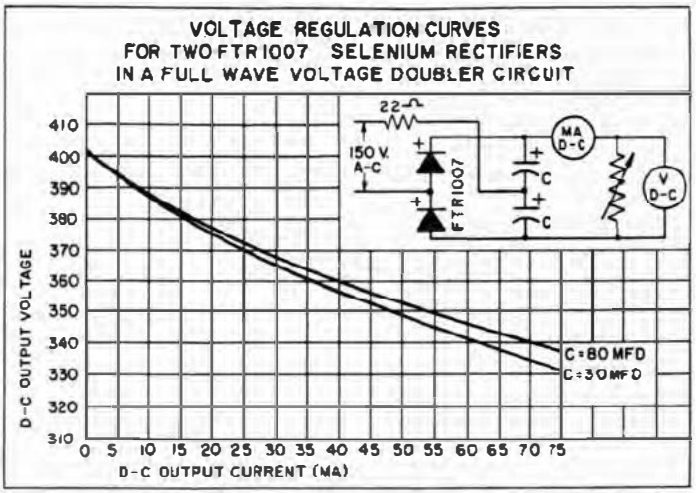
(as applied to a single section)

Rated RMS Input Voltage	150
Max. RMS Input Voltage	160
Max. Peak Inverse Voltage	460
Max. Peak Current (Ma)	750
Max. RMS Current (Ma)	200
Max. D-C Current Output (Ma)	75
Approx. Rectifier D-C Voltage Drop	9
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

The Federal 1007 selenium rectifier was developed for application in 75 MA vibrator power supplies. Characteristic curves for this rectifier when employed in a full wave doubler circuit with a 150 volt, 60 cycle input are shown below. It should be noted, however, that the output of a vibrator transformer secondary in many cases will not be equal to 150 volts and hence the selenium rectifiers developed for use in vibrator power supplies have a higher RMS voltage rating—allowing for variations in vibrator outputs. For an input other than 150 volts the designer must interpolate the curves shown below to obtain an approximation of the output to be expected. An additional factor that should be considered when utilizing these curves is that the data was taken with a 60 cycle sine wave input—while the vibrator may operate at a different frequency and have a square waveform.



Federal SELENIUM RECTIFIER

FTR MODEL 1008

100 MA, DOUBLER

ELECTRICAL CHARACTERISTICS

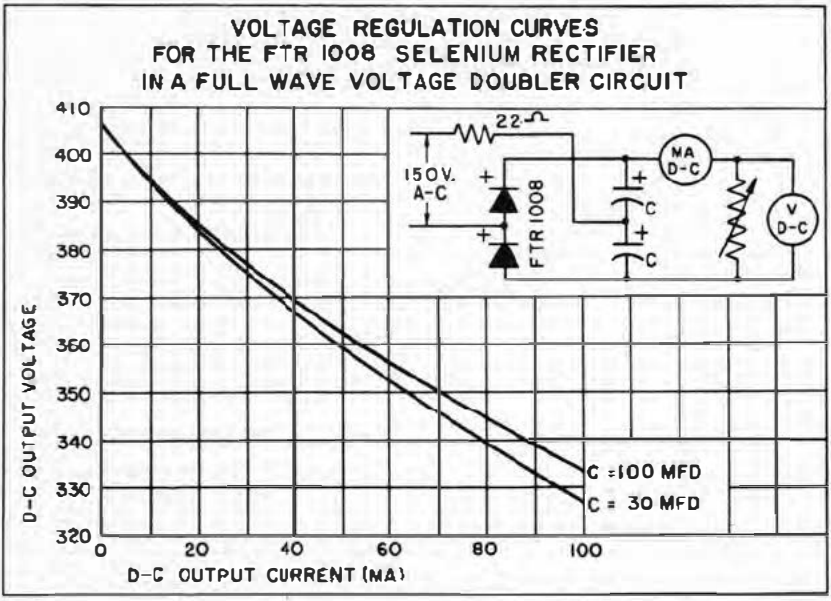
(as applied to a single section)

Rated RMS Input Voltage	150
Max. RMS Input Voltage	160
Max. Peak Inverse Voltage	460
Max. Peak Current (Ma)	1000
Max. RMS Current (Ma)	270
Max. D-C Current Output (Ma)	100
Approx. Rectifier D-C Voltage Drop	9
Minimum Series Resistance (ohms)	22
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

CIRCUIT APPLICATION

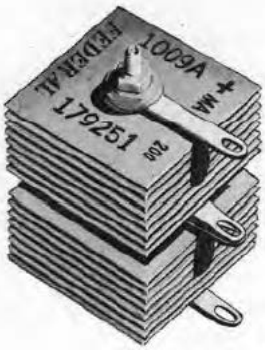
The Federal 1008 selenium rectifier was developed for use in 100 ma vibrator power supplies. This unit is actually electrically similar to two 1014 units assembled together. The characteristic curves for this rectifier employed in a full wave doubler circuit with a 150 volt input are shown below. As indicated in the "Circuit Application" of the 1007 rectifier, in many cases a 150 volt and sine wave input will not be obtained from the vibrator transformer secondary—in which case the designer must approximate the output to he expected.



Federal SELENIUM RECTIFIER

FTR MODEL 1009

200 MA, DOUBLER



ELECTRICAL CHARACTERISTICS

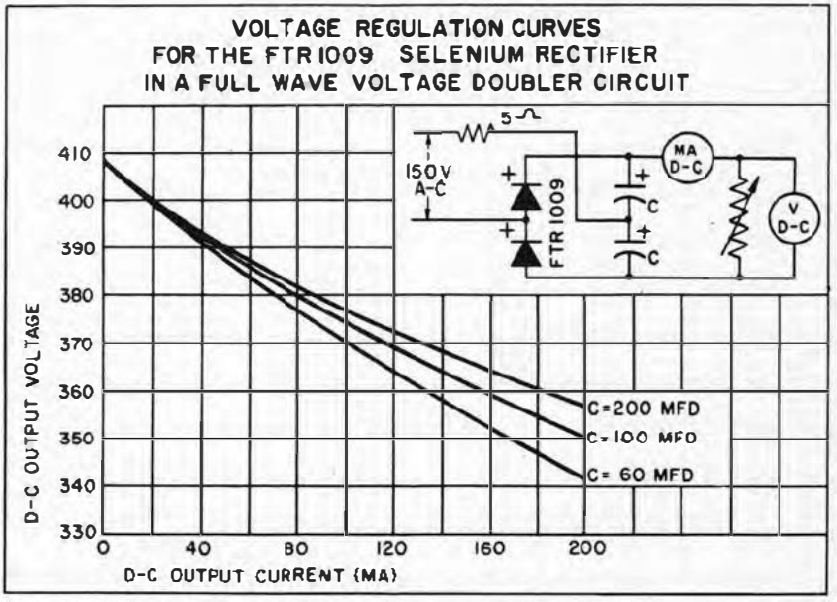
(as applied to a single section)

Rated RMS Input Voltage	150
Max. RMS Input Voltage	160
Max. Peak Inverse Voltage	460
Max. Peak Current (Ma)	2000
Max. RMS Current (Ma)	540
Max. D-C Current Output (Ma)	200
Approx. Rectifier D-C Voltage Drop	9
Minimum Series Resistance (ohms)	5
Max. Cell Operating Temperature (°C)	85

For Dimensions, See Table, Page 11

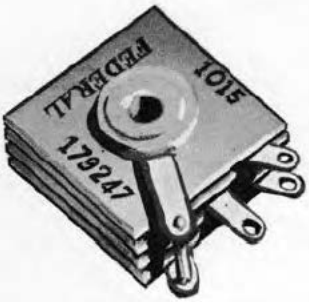
CIRCUIT APPLICATION

The Federal 1009 selenium rectifier was developed for use in 200 ma vibrator power supplies. The characteristic curves for this rectifier employed in a full-wave doubler circuit with a 150 volt input are shown below. As indicated in the description of the 1007 rectifier, the 150 volt and sine wave input will, in many cases, not be obtained from the vibrator transformer secondary—in which case the designer must approximate the output to be expected.

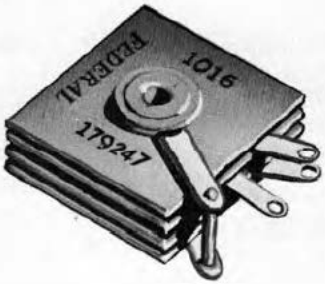


Federal SELENIUM RECTIFIERS

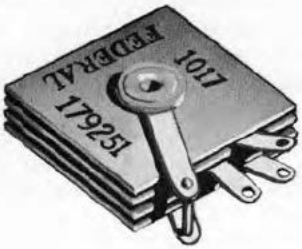
25 VOLT, BRIDGE CONNECTION



FTR Model
1015
150 MA



FTR Model
1016
300 MA



FTR Model
1017
600 MA

CHARACTERISTICS

FTR Model No.	Max. Peak Current (MA)	Max. RMS Current (MA)	Max. D.C (MA) Current Output
1015	750	175	150
1016	1500	350	300
1017	3000	700	600

The following characteristics apply for all 25 Volt Bridge Connection Rectifiers:

Max. RMS Input Voltage 25
Max. Peak Inverse Voltage 35
Max. Cell Operating Temperature (°C) 85

Federal 25 VOLT, BRIDGE CONNECTION SELENIUM RECTIFIER

DIMENSIONS IN INCHES *(See dimensional diagram p. 10, Fig. 1)*

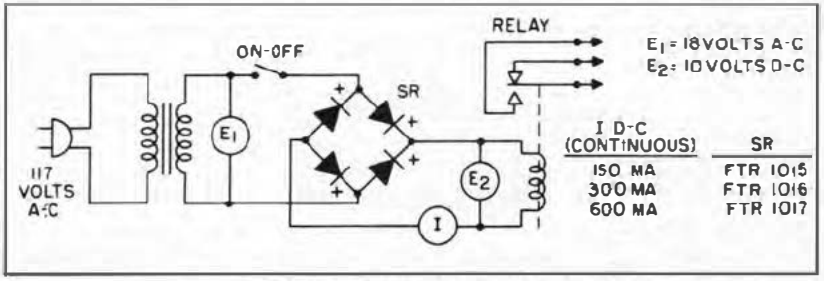
FTR Model No.	A	B	D	I
1015	19/64	1	1	5/64 x 5/32
1016	23/64	1 13/64	1 9/32	5/64 x 5/32
1017	7/16	1 17/32	1 17/32	3/32 x 3/16

All Types Have the Following Dimensions:

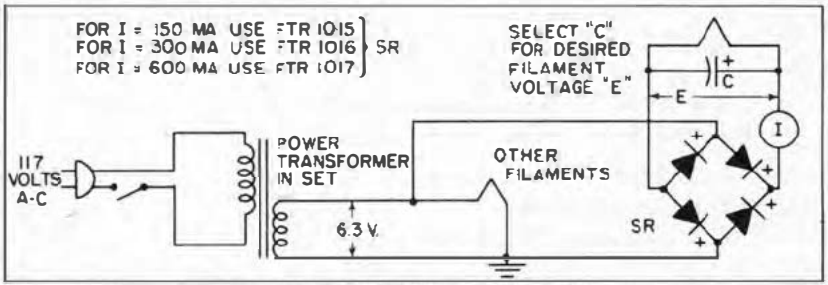
H (Max.) .....¾ J.....9/64 Dia. (No Locking Lug)

CIRCUIT APPLICATION

Federal's 25 volt, bridge connection selenium rectifiers provide an economical and efficient method of supplying d-c power in applications where low voltages—up to 25 volts RMS input—and comparatively high current—up to 600 Ma d-c—are required. Two typical supplies are shown below. It should be noted that all four rectifier arms are contained within each bridge rectifier—each selenium rectifier cell comprising one arm. In applications where intermittent rather than continuous operation is required, a higher value of maximum d-c current can be used—providing the cell operating temperature does not exceed 85°C.



SOLENOID AND RELAY POWER SUPPLY

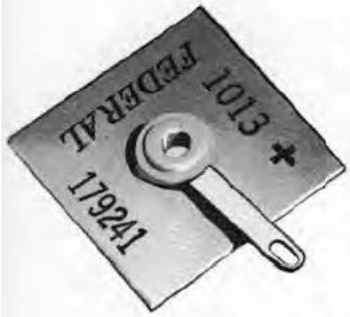


D-C FILAMENT SUPPLY

Federal SELENIUM RECTIFIER

FTR MODEL 1013

SINGLE CELL, HALF WAVE



ELECTRICAL CHARACTERISTICS

In half-wave applications with resistive load—

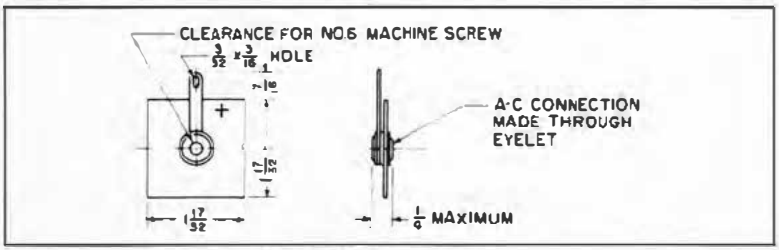
Max. RMS Input Voltage	18
Max. D-C Current (Ma)	450

In half-wave applications with capacitive load

Max. RMS Input Voltage	9
Max. D-C Current (Ma)	360
Max. Cell Operating Temperature (°C)	85

In half-wave battery charging applications—

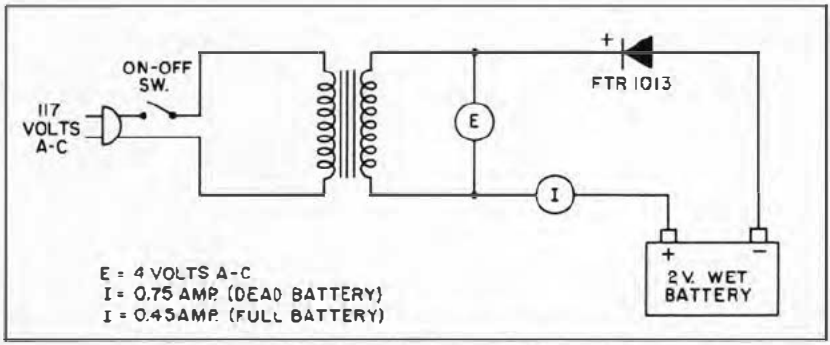
No. Cells	*RMS Input Voltage*	*Charging Current (amp) Fully Charged*	*Dead*
1	4	.45	.75
3	8	.45	.75



DIMENSIONAL DIAGRAM

CIRCUIT APPLICATION

The Federal 1013 selenium rectifier was developed primarily for use in 2 and 6 volt battery chargers such as are used in self-charging portables. The schematic diagram of a typical charger using the rectifier is shown below. The 1013 can also be used as a low voltage filtered or unfiltered power supply such as the bias and filament supplies described for the FTR 1001 rectifier.



TYPICAL 2 VOLT HALF WAVE BATTERY CHARGER

Federal SELENIUM RECTIFIER

FTR MODEL 1018

CENTER TAPPED RECTIFIER

ELECTRICAL CHARACTERISTICS

In full wave applications with resistive load—

Max. RMS Input voltage 26

Max. D-C Current (Ma) 1800

In full wave applications with capacitive load

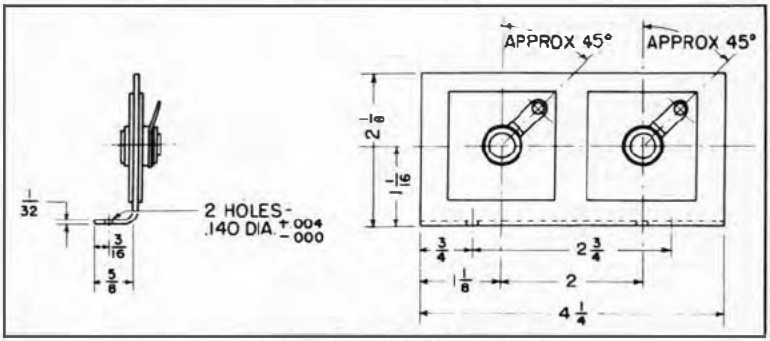
Max. RMS Input Voltage 26

Max. D-C Current 1600

Max. Cell Operating Temperature (°C).. 85

In full wave battery charging applications—

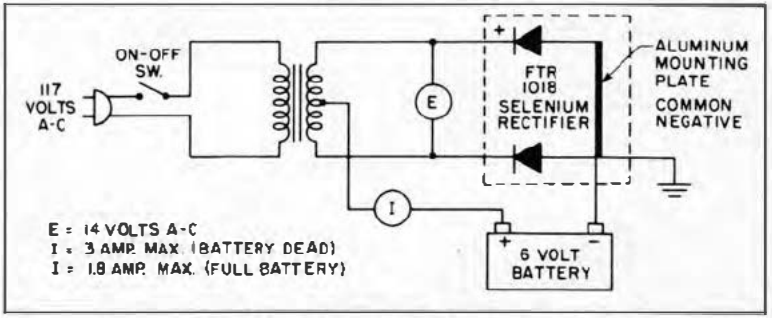
No. Cells	*RMS Input Voltage*	*Charging Current (amp) Fully Charged*	*Dead*
3	15	1.8	3.0



DIMENSIONAL DIAGRAM

CIRCUIT APPLICATION

The Federal 1018 selenium rectifier was developed for use in trickle battery charging equipment for recharging 6 volt batteries. A typical recharger circuit is shown below. This circuit can also be used for d-c filament supplies.



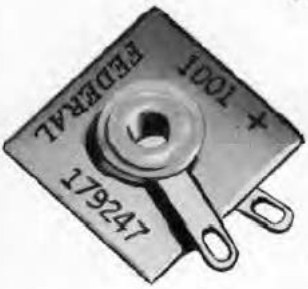
TYPICAL 6 VOLT TRICKLE CHARGER

Federal SELENIUM RECTIFIER

FTR MODEL 1001

75 MA, 20 V

SINGLE CELL, HALF WAVE



ELECTRICAL CHARACTERISTICS

Max. RMS Input Voltage	20
Max. Peak Inverse Voltage	35
Max. Peak Current (Ma)	750
Max. RMS Current (Ma)	200
Max. D-C Current (Ma)	75
Max. Cell Operating Temperature (°C)	85

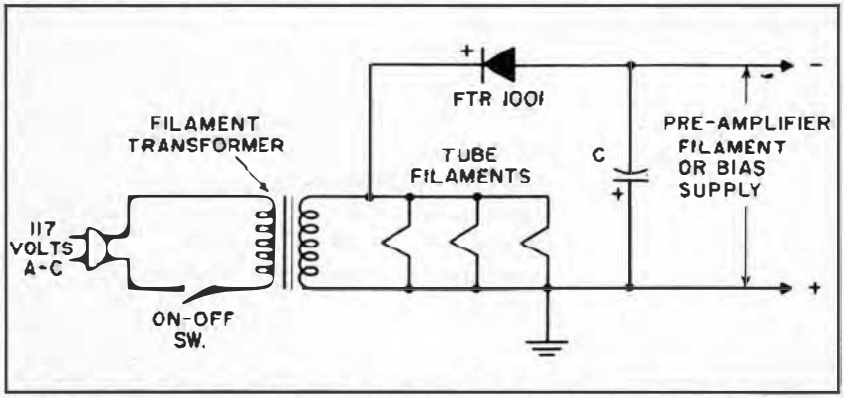
DIMENSIONS IN INCHES *(See dimensional diagram p.10, Fig. 1)*

A	19/64	D	1	G	*	J	9/64 Dia.
B	1	E	*	H (Max.)	3/8	K	*
C	*	F	*	I	5/64x5/32		

*(No Locking Lug)

CIRCUIT APPLICATIONS

The Federal 1001 selenium rectifier was developed for application in bias supplies where relatively low voltage is required. When only one rectifier is utilized, the maximum voltage and current output of such a bias supply would be 20 volts, at 75 milliamperes. However, it is possible to increase these maximum ratings by adding rectifiers in series for greater voltages, or in parallel for higher current outputs. For example, in designing an audio amplifier it is particularly advantageous to utilize d-c for the pre-amplifier filament. This can be done by use of a half-wave rectifier circuit in series with that filament as shown in the schematic below. If the filament requires 150 ma, then two Model 1001 rectifiers would be used in parallel—if 300 ma is necessary then four in parallel would be employed.



BIAS OR FILAMENT SUPPLY USING FILAMENT VOLTAGE SOURCE

SECTION II

Design and Service Data

for

Federal

SELENIUM RECTIFIERS

On the following pages Federal presents design and service data of interest to engineers and technicians.

- **Applications**
- **Circuit Diagrams**
- **Service Information**
- **Replacement Kits**

Included in this section are schematic diagrams that can be used in the following types of equipment:

- **Television Receivers**
- **AM-FM Home Receivers**
- **Phonograph**
- **Audio Amplifiers**
- **Combination Sets**
- **Mobile**
- **Amateur**
- **Industrial**

Applications

The field of application of Federal selenium rectifiers continues to broaden at a rapid rate. The small size and weight, and the low cost of this rectifier, plus its favorable electrical characteristics of long life, instantaneous rectification, and ability to withstand heavy surge currents have resulted in the design of more economical and improved radio and electronic equipment.

The many circuit suggestions shown in the succeeding pages by no means cover all the possible rectifier applications or designs. They are offered to supply ideas and guidance for the engineer, who can modify any of the circuits to suit his individual requirements. Federal, with a corps of specialized personnel, will gladly assist the designer in perfecting any circuit utilizing these rectifiers.

Some typical selenium rectifier applications are listed below:

Home Radios

Portable Radios

Television Receivers and Transmitters

Television Boosters

Audio Amplifiers

Phonograph Oscillators

Record Players

Speaker Field Power Supplies

DC Field Power Supplies

Relay Power Supplies

Solenoid Power Supplies

Business Machines

Laboratory Equipment

Battery Trickle Charges

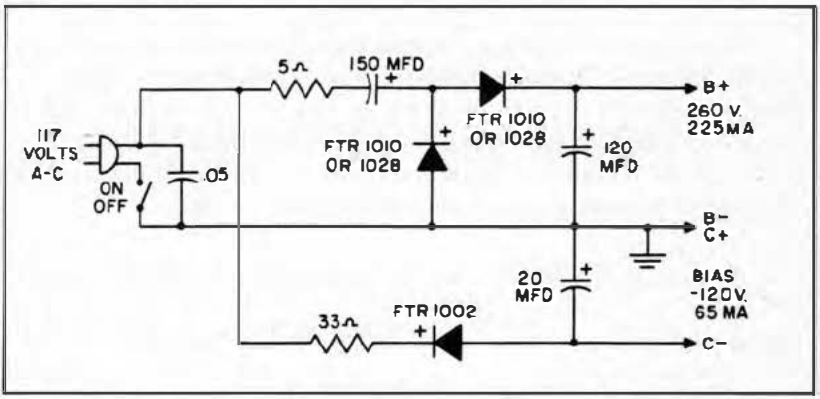
Fan Power Supplies

DC Motor Power Supplies

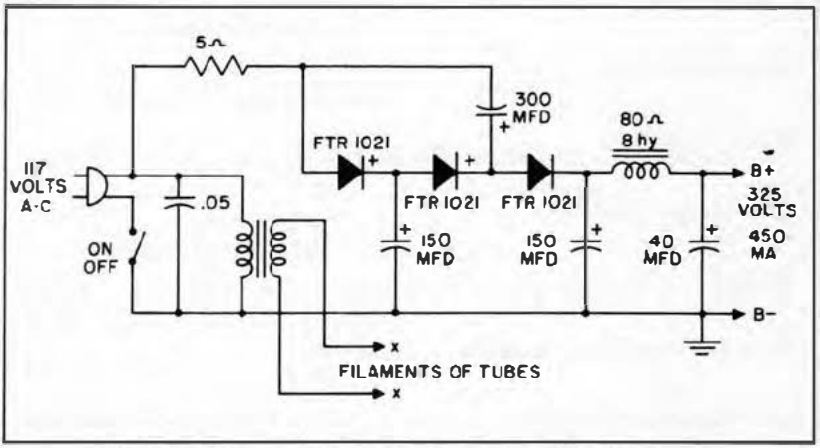
Electric Razors, and any other application requiring DC current from a 117 volt line.

TELEVISION RECEIVERS

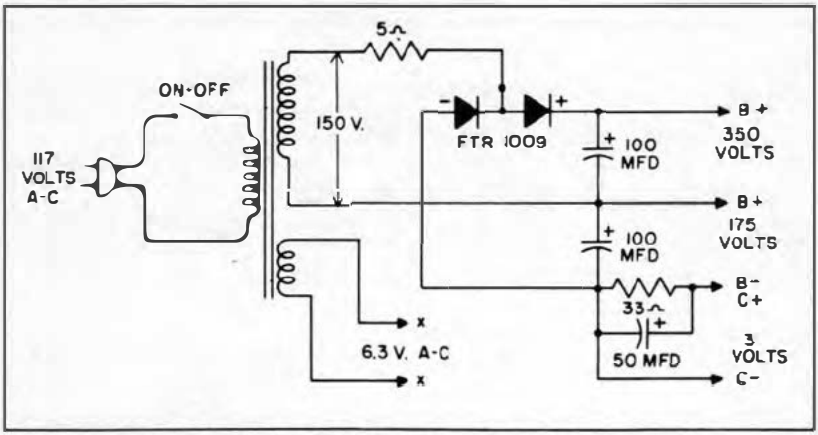
Federal's selenium rectifiers, by eliminating the need for power transformers and rectifier tubes, have been a major factor in the development of lower cost, lighter television receivers. In addition to their use in smaller sets, these rectifiers, due to their efficiency and flexibility, offer many design advantages in larger units where special circuits can be incorporated to improve equipment design with very little cost increase. On succeeding pages, Federal presents a number of circuit suggestions that can be used in various types and sizes of television receivers.



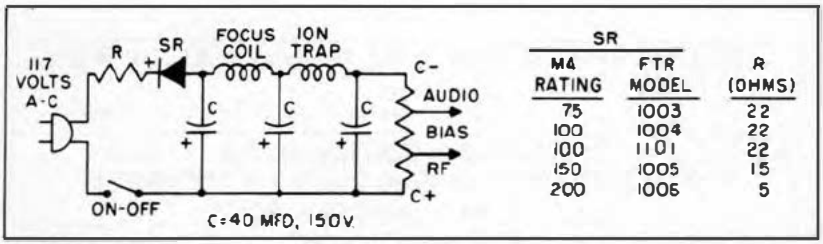
TYPICAL VOLTAGE DOUBLER WITH BIAS SUPPLY



POWER SUPPLY FOR LARGE TELEVISION RECEIVERS

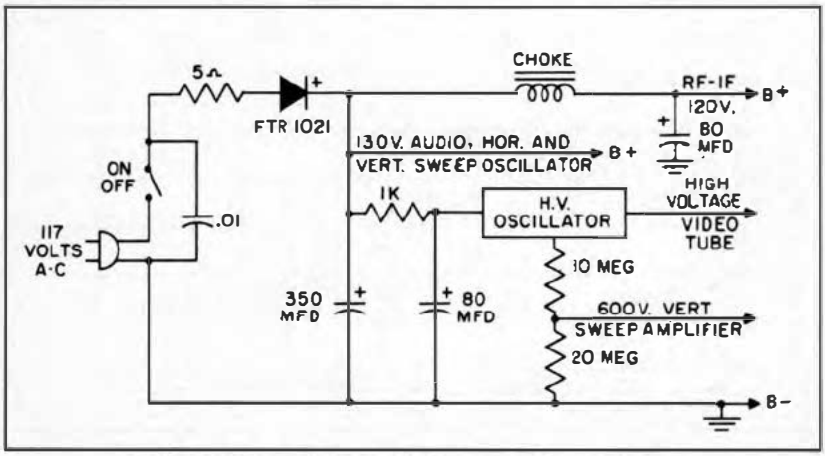


B+ AND BIAS SUPPLY FOR TELEVISION RECEIVERS

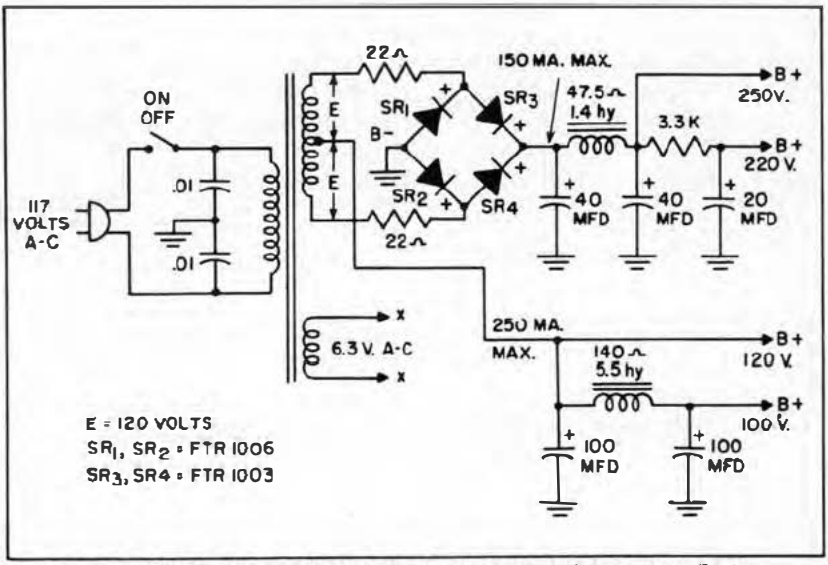


SR		
MA RATING	FTR MODEL	R (OHMS)
75	1003	22
100	1004	22
100	1101	22
150	1005	15
200	1006	5

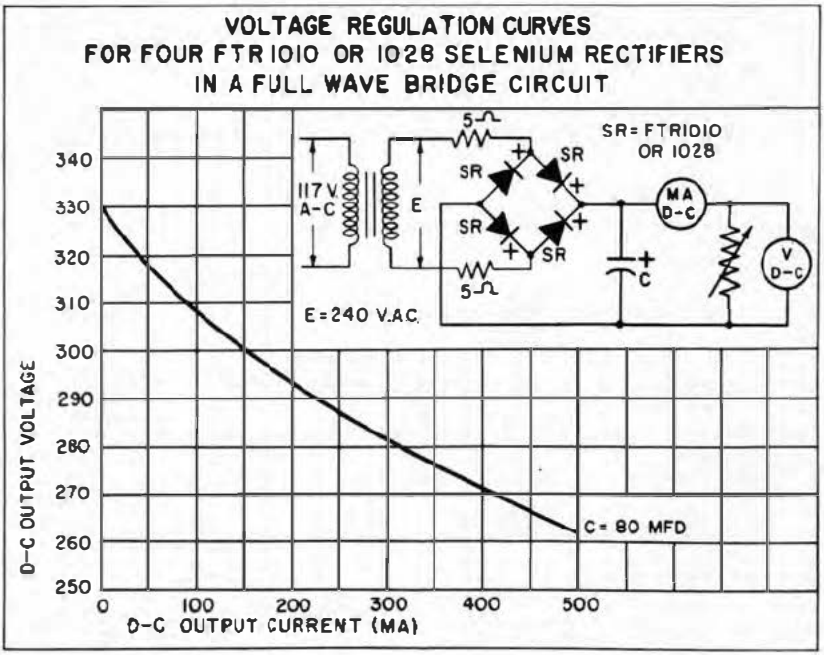
FOCUS AND BIAS POWER SUPPLY FOR TELEVISION RECEIVERS

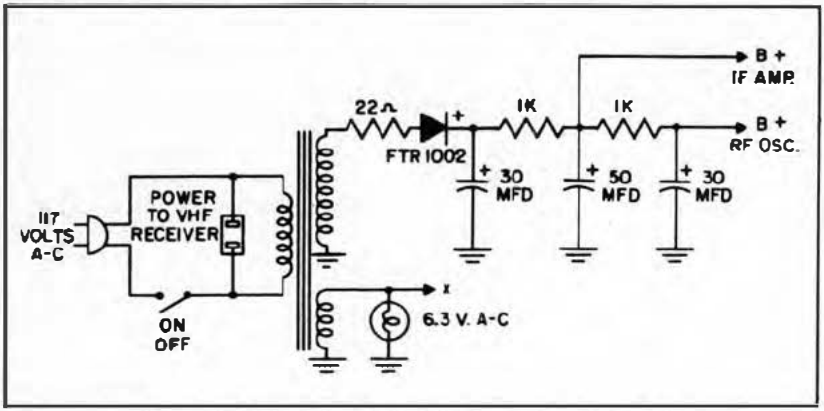


AC-DC AND PORTABLE TELEVISION POWER SUPPLY

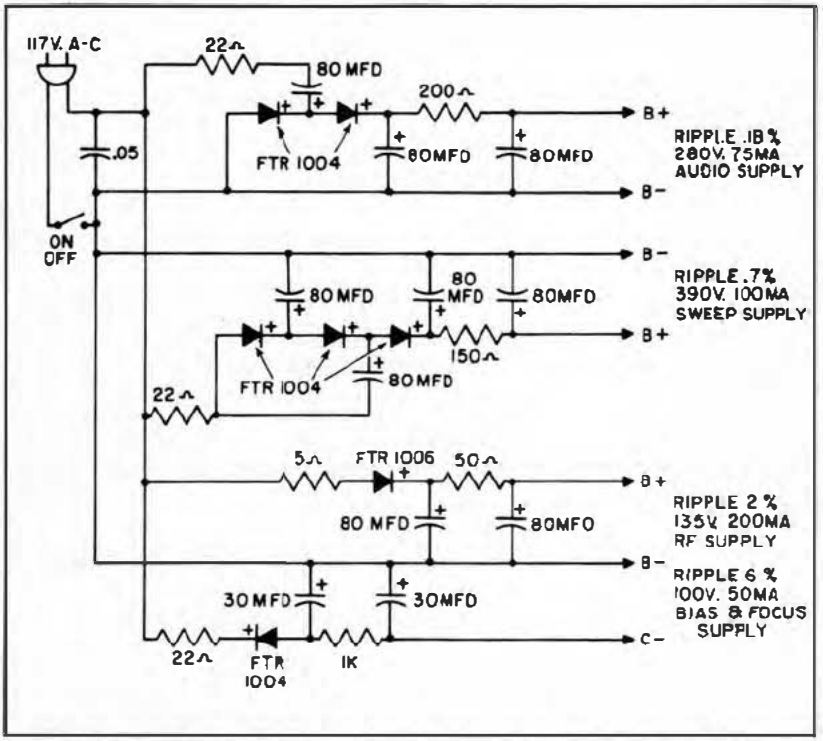


FULL WAVE POWER SUPPLY FOR TELEVISION RECEIVERS





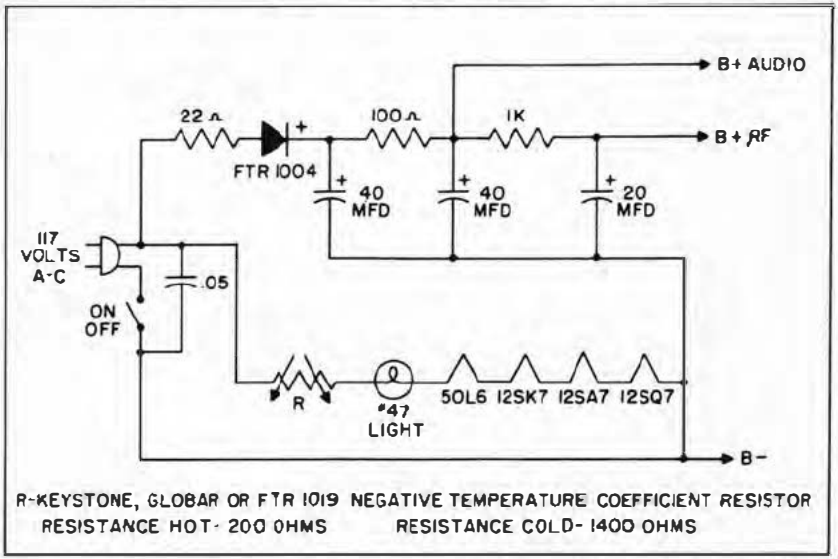
POWER SUPPLY FOR 2 CHANNEL UHF CONVERTER



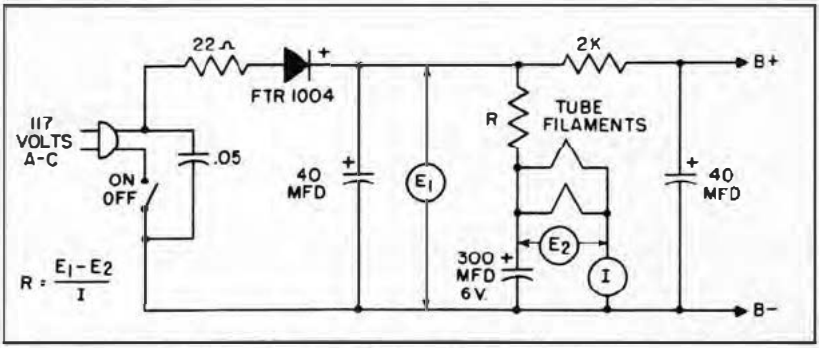
MULTIPLE POWER SUPPLY FOR HIGH QUALITY TELEVISION RECEIVERS

AM-FM HOME RECEIVERS

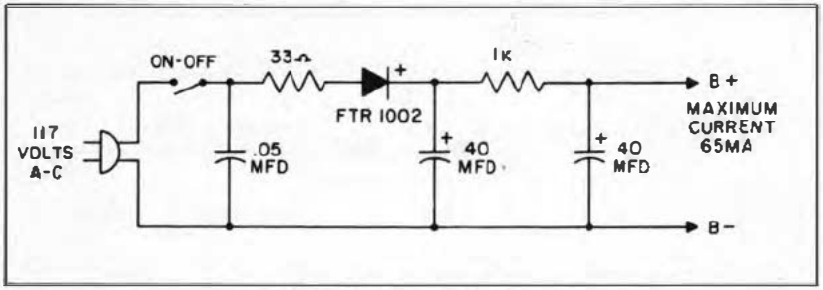
Federal selenium rectifiers have been widely accepted by leading radio manufacturers as a standard component in all types of portable, table model, console, phonograph and combination radio-phonograph sets. A few of the features that dictate the use of selenium rectifiers are: reduced internal heat, due to elimination of the rectifier tube filament; increased sensitivity because of the higher efficiency and greater power output of a B+ supply using selenium rectifiers; and in portables having directly heated cathodes, the instant starting feature. Furthermore, at a very little increase in cost, it is possible to separate bias supplies, reduce filament hum, and achieve many other improvements in design. Schematic diagram for circuits used in various home receivers, phonographs, audio amplifiers, and combination sets are shown in succeeding pages.



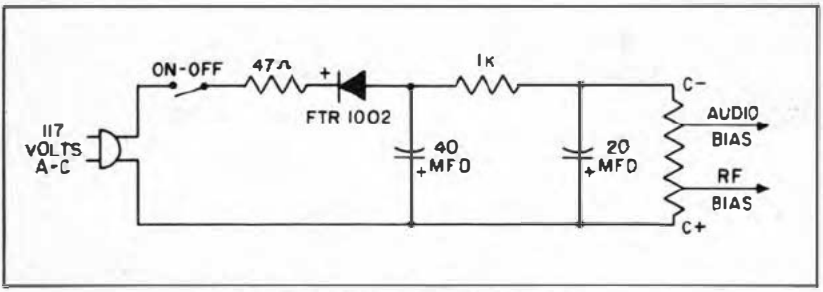
TYPICAL AC-DC POWER SUPPLY USING THE FTR 1004 SELENIUM RECTIFIER FOR THE B+ SUPPLY AND A N.T.C. RESISTOR IN THE FILAMENT SUPPLY TO GIVE LONGER LIFE TO TUBES & PILOT LIGHT.



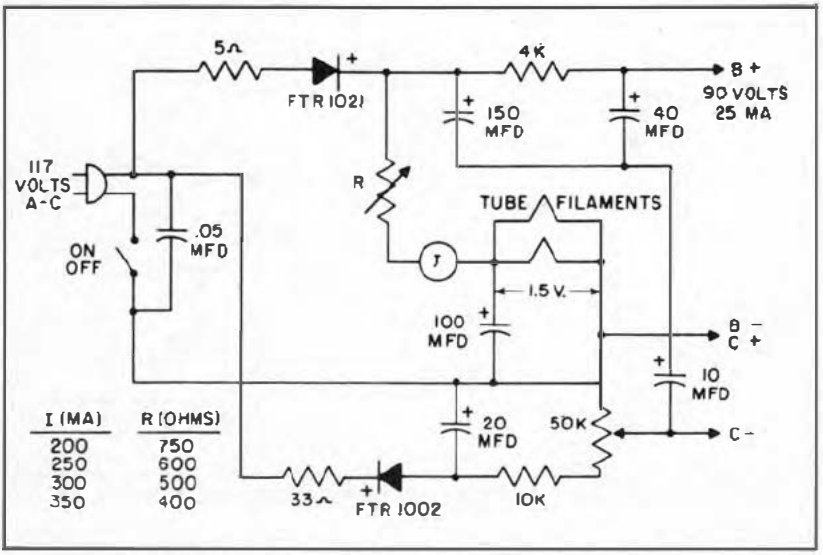
TYPICAL 3-WAY PORTABLE POWER SUPPLY



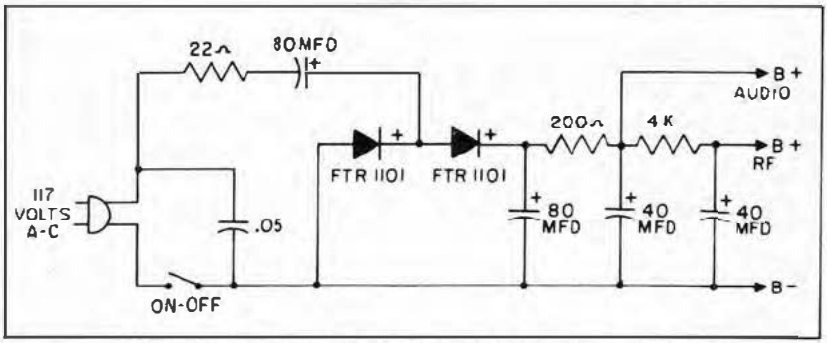
65 MA B+ POWER SUPPLY



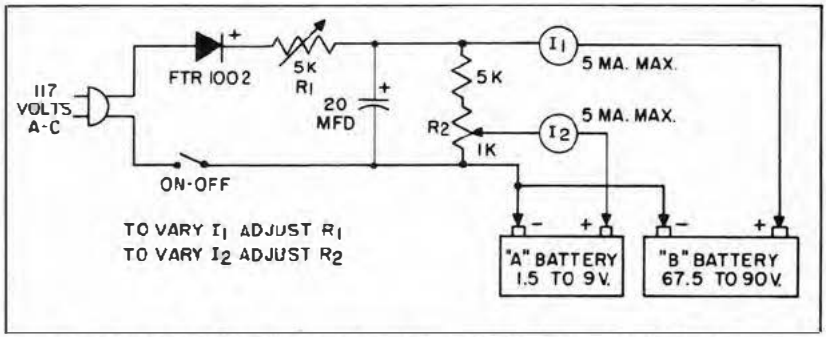
65 MA BIAS POWER SUPPLY



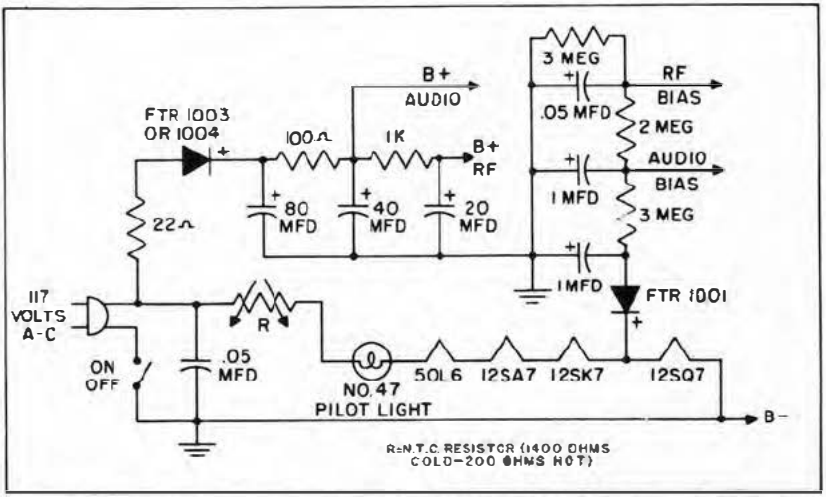
B+, BIAS AND FILAMENT SUPPLY FOR FARM RADIOS



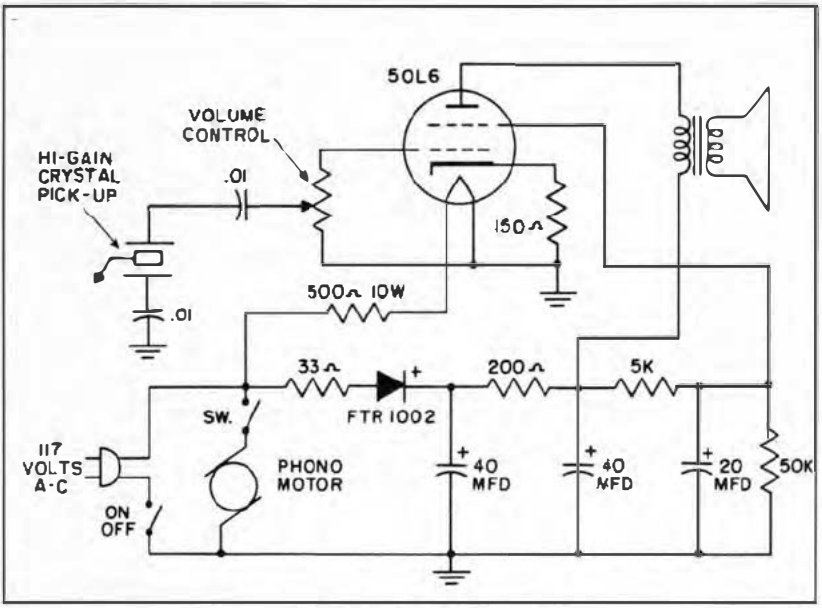
TYPICAL B+ POWER SUPPLY FOR HOME RECEIVERS



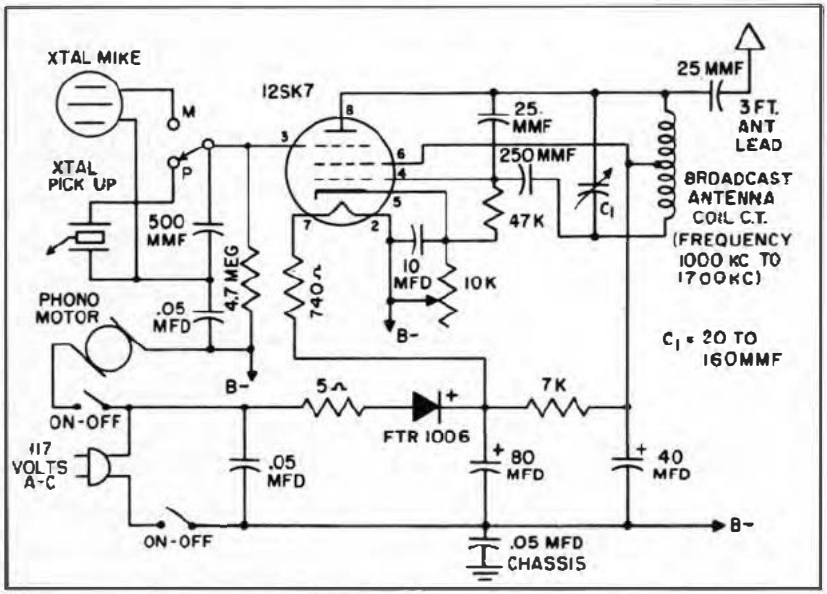
BATTERY CHARGER FOR PORTABLE DRY CELL BATTERIES



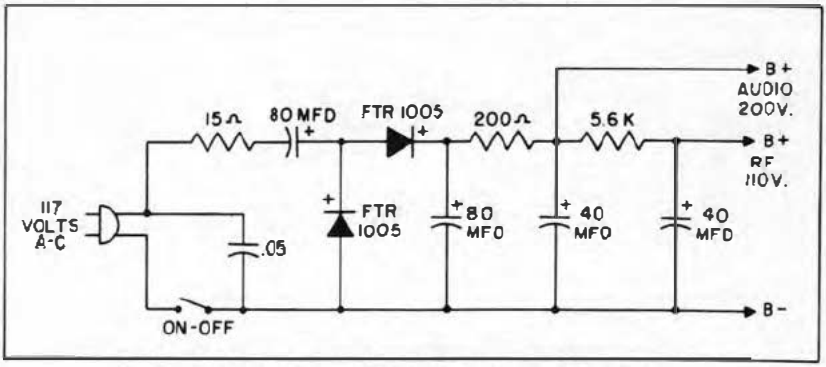
BIAS AND B+ POWER SUPPLY FOR HOME RECEIVERS



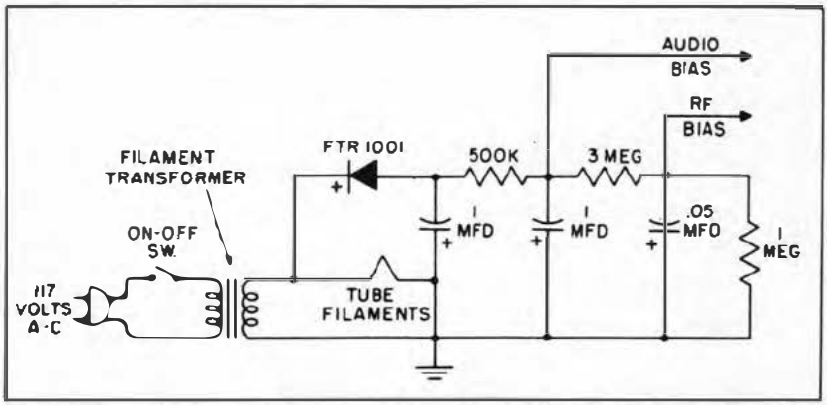
PHONOGRAPH AMPLIFIER



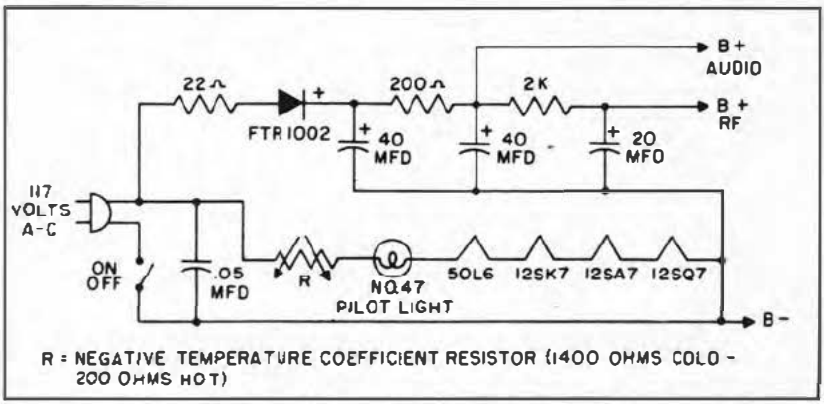
PHONOGRAPH OSCILLATOR



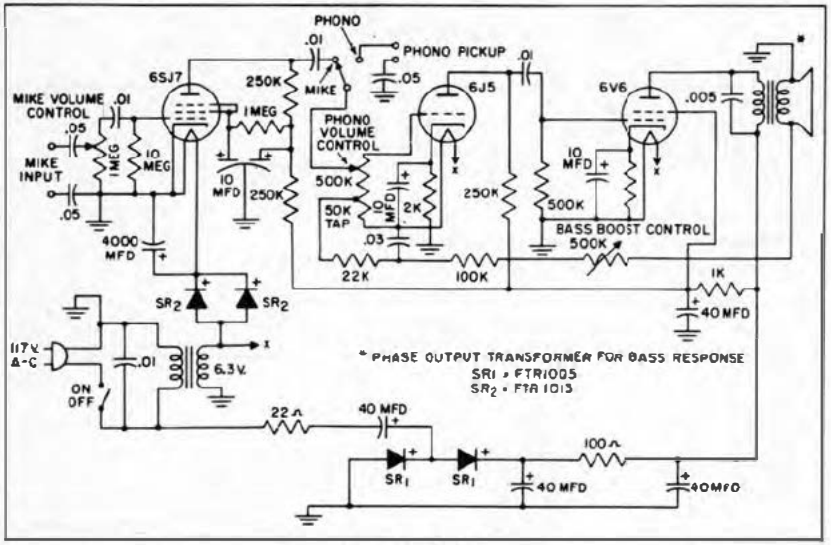
B+ SUPPLY FOR CONSOLE COMBINATIONS



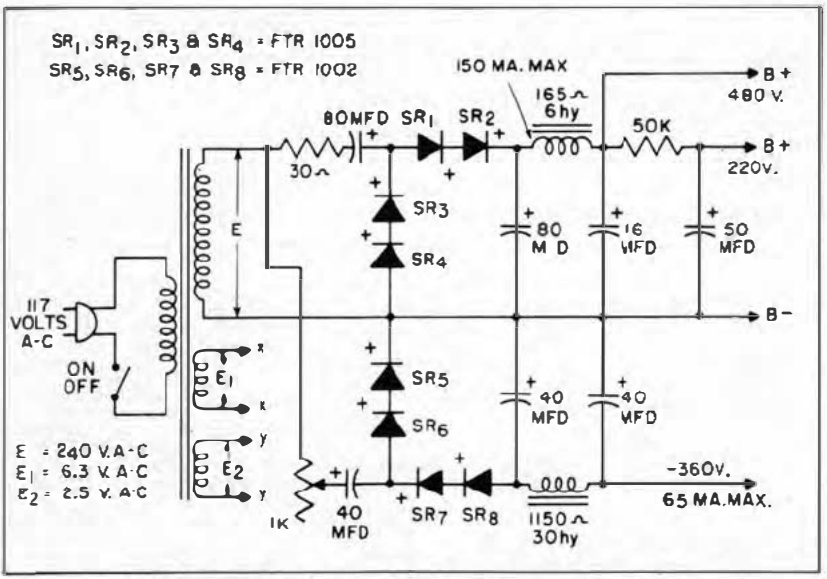
RF AND AUDIO BIAS SUPPLY UTILIZING FILAMENT VOLTAGE SOURCE



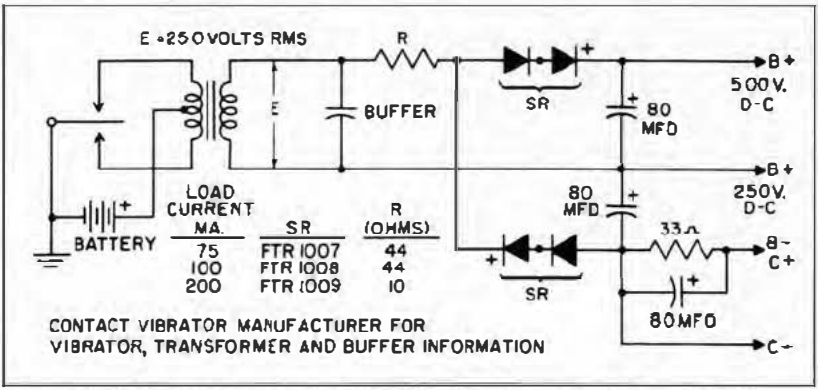
RADIO PHONOGRAPH POWER SUPPLY



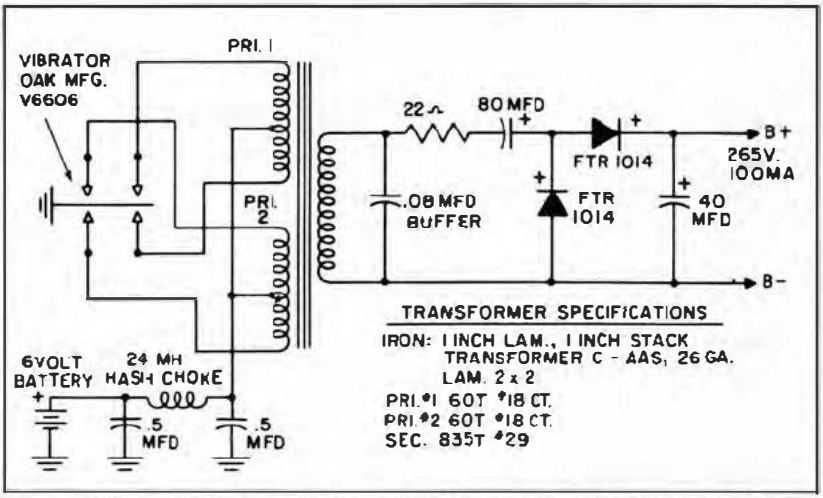
AUDIO AMPLIFIER



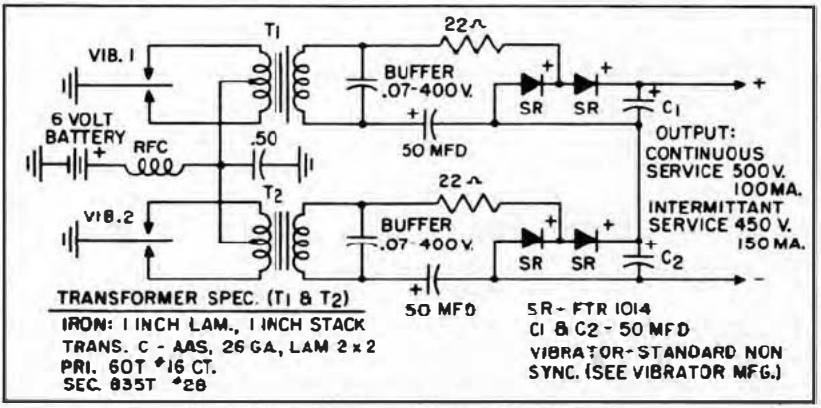
DUAL VOLTAGE DOUBLER POWER SUPPLY, WITH COMMON B-, FOR "HIGH-FIDELITY" AUDIO AMPLIFIERS



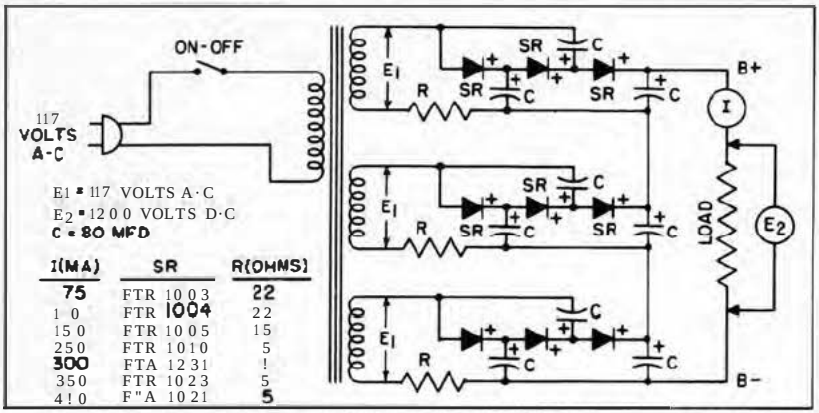
TYPICAL FULL WAVE DOUBLER VIBRATOR POWER SUPPLY



MOBILE POWER SUPPLY WITH TRANSFORMER SPECIFICATIONS

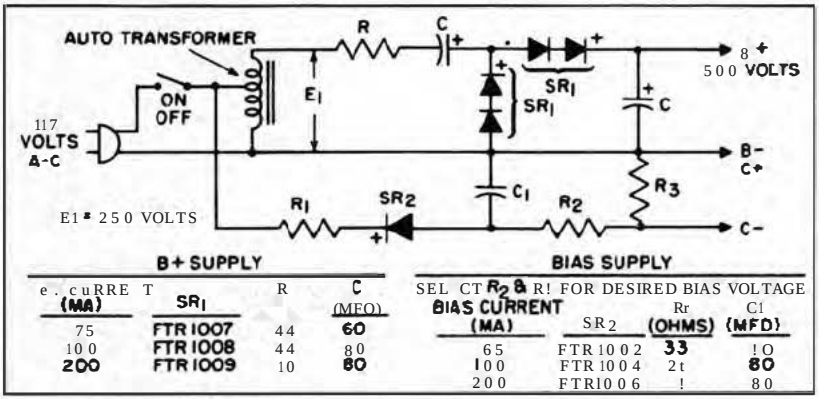


B+ AND BIAS MOBILE POWER SUPPLY



I(MA)	SR	R(OHMS)
75	FTR 1003	22
100	FTR 1004	22
150	FTR 1005	15
250	FTR 1010	5
300	FTA 1231	!
350	FTR 1023	5
410	F"A 1021	5

HIGH VOLTAGE POWER SUPPLY FOR AMATEUR TRANSMITTERS



B+ SUPPLY

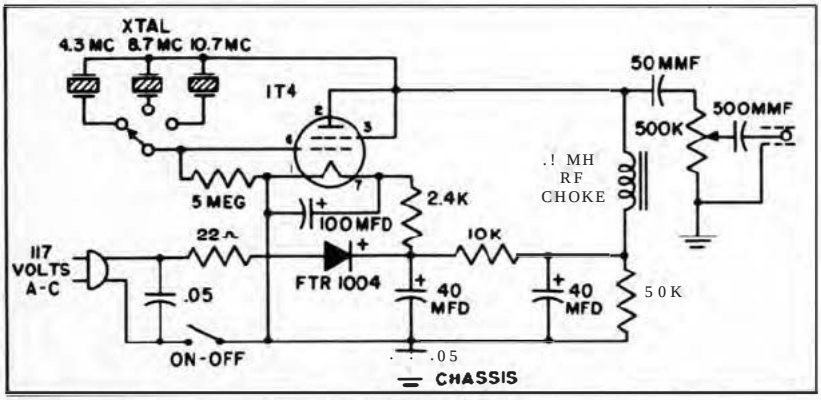
e. cuRRE T (MA)	SR1	R	C (MFD)
75	FTR 1007	44	60
100	FTR 1008	44	80
200	FTR 1009	10	60

BIAS SUPPLY

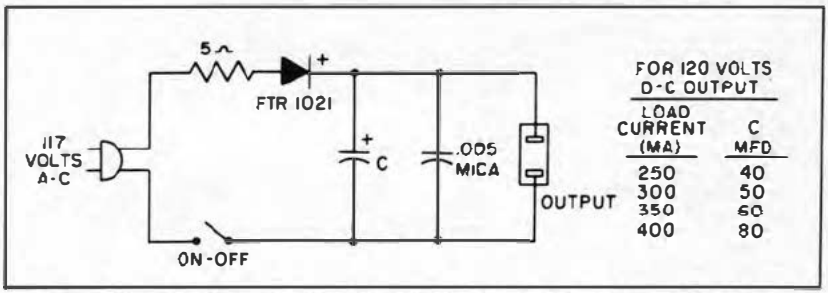
SEL CT R2 & R! FOR DESIRED BIAS VOLTAGE

BIAS CURRENT (MA)	SR2	Rr (OHMS)	C1 (MFD)
65	FTR 1002	33	!0
100	FTR 1004	2t	60
200	FTR1006	!	80

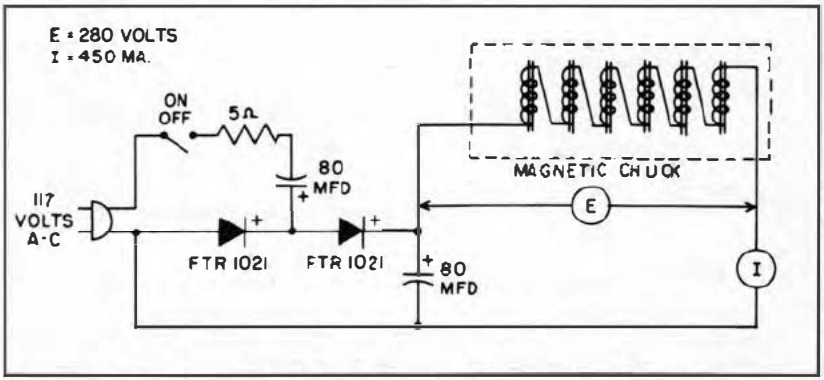
500 VOLT B+ AND BIAS SUPPLY FOR AMATEUR TRANSMITTERS



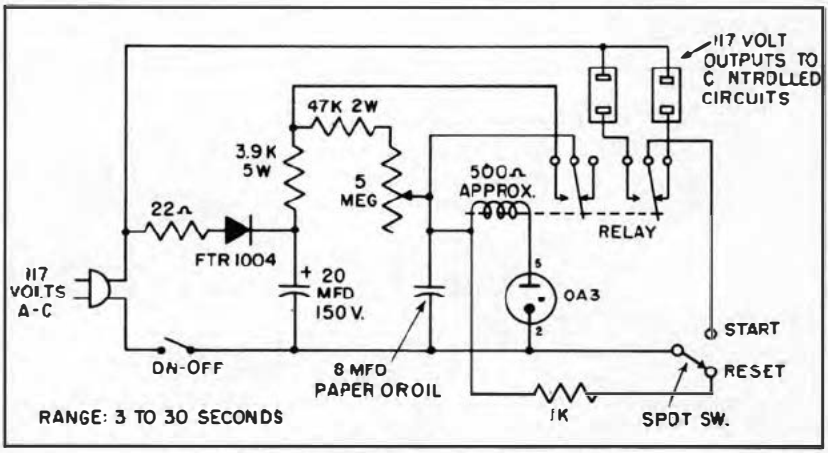
TEST OSCILLATOR



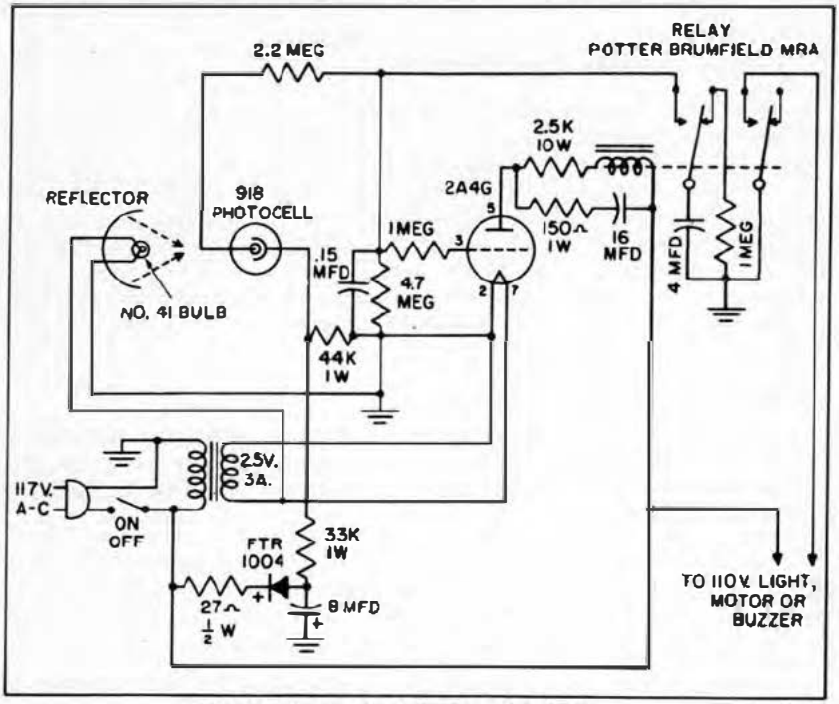
D-C POWER SUPPLY FOR POWERING ELECTRIC FANS, RELAYS AND SIMILAR DEVICES



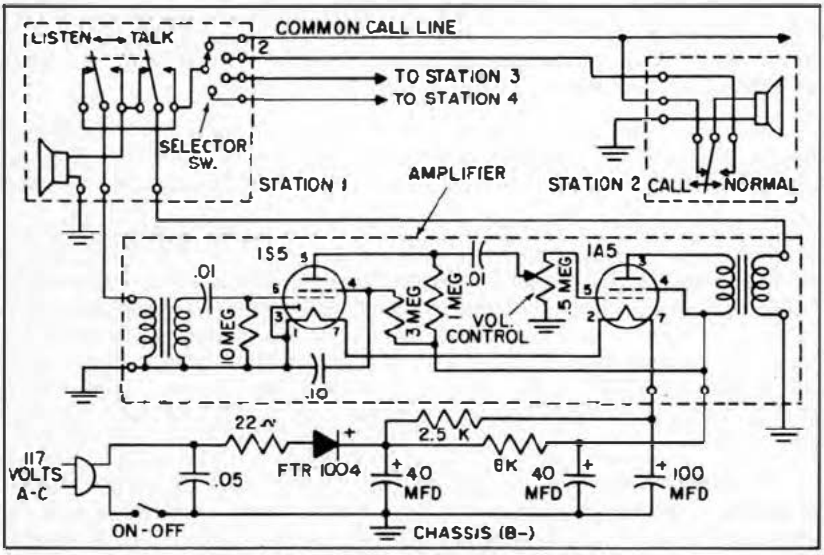
D-C POWER SUPPLY FOR POWERING MAGNETIC CHUCKS



D-C POWER SUPPLY FOR TIMER



PHOTOCELL AMPLIFIER CIRCUIT



INTERCOMMUNICATIONS SYSTEM

SERVICING INFORMATION

1. *Testing the Selenium Rectifier*

While the selenium rectifier has been found to be a long lived and trouble free component, instances do occur when it is important to know how to install them properly and test them when a radio or television set is in trouble. Faulty operation may result from the rectifier becoming open circuited, short circuited, high in forward resistance, or low in reverse resistance. If trouble occurs a visual inspection of the rectifiers and other components of the power supply may show whether replacement is necessary. As failure is not always accompanied by physical changes, an electrical test may be necessary to determine whether the rectifier is damaged.

2. *Removal and Replacement*

In soldering or unsoldering of leads to a selenium rectifier, the heated soldering iron should not be brought in contact with the cells making up the rectifier. The heat may melt the alloy on the cells or damage the protective coating.

The rectifier should be replaced in its original position, or in a position which provides better cooling. Best cooling is obtained when the rectifier is mounted with the cells vertical and when the passage of air through the cells is not restricted at the top or bottom.

When replacing a rectifier be sure that it is firmly fixed in place so that it cannot turn and come in contact with the chassis, other components, or wiring of the set. Any barriers provided by the set manufacturer for this purpose which have become damaged should be replaced.

The rectifier has been given a moisture resistant coating before leaving the factory. Additional coatings should not be applied unless it is first determined from the manufacturer that the coating to be used will not affect the rectifier.

Mercury vapor is very harmful to selenium rectifiers and will destroy the rectifying action even though they have been coated. Any mercury remaining due to a broken mercury vapor tube should be carefully removed.

A line resistor is connected in series with the rectifier in radio and television sets. While omission of this resistor will increase the voltage of the B+ supply, it serves an important purpose in protecting the rectifier and condenser from heavy surge currents. These currents may damage or shorten the life of the rectifier and/or electrolytic condenser. In some sets the resistor rating has been selected so that it will burn out on overload, thus protecting more expensive components against burnout. Replacement of a burned line resistor should be made with another of the same type and rating.

A damaged rectifier may result from failure of the rectifier or faulty operation of the components of the set. When a selenium rectifier must be replaced, the current draw of the B+ circuit should be checked to be sure it is within the rating of the rectifier. The cabinet and chassis should be

checked to be sure that ventilating openings have not been blocked off, or restricted, preventing proper cooling.

3. *Visual Inspection*

Trouble may be indicated by melting of the alloy which covers most of one side of each cell and which forms the cathodes of the rectifier. Such melting may be due to excessive temperature of the rectifier caused by current overload, or by restricted ventilation causing the temperature of the rectifier to rise above the melting point of the alloy. The melting may be indicated by a thickening of the alloy at the bottom edge of the cells or by the presence of drops of solderlike metal below the rectifier.

Inspection of the alloy area at the center of the cells around the contact washer may show burning or discoloration. A burning all around the contact washer may result in an open circuit and the rectifier should be replaced. Discolored or burned spots may be observed on the alloy away from the contact washer. These spots have been caused by sparking on the cells resulting from application of higher than rated voltage to the rectifier. They may also occur when voltage is first applied after a long period of idleness. These spots are self-healing and will not affect the operation of the rectifier unless an area equal to about 20 percent of a cell has been burned, or unless sparking is persistent. In either case the rectifier should be replaced.

4. *Troubles Found in Selenium Rectifiers*

The troubles found in selenium rectifiers will generally appear under one of the following classifications:

(a) Open circuited rectifier resulting in no B+ voltage.

(b) High forward resistance rectifier resulting in low B+ voltage.

(c) Short circuited rectifier resulting in burned out line resistor or opening of circuit protecting device.

(d) Low reverse resistance rectifier resulting in low B+ voltage and/or hum in loud-speaker of set.

(e) Overheated selenium rectifier resulting in melted alloy on the rectifier cells and any of the troubles listed above.

5. *Ohmmeter Test*

An ohmmeter of the conventional type employing a battery and meter for measuring resistance may be used for a rough check of a selenium rectifier.

Place the leads from the ohmmeter on the terminals of the rectifier in one direction and then reverse them, reading the resistance each time. Two high resistance readings will indicate an open circuited rectifier. Two low resistance readings will indicate a short circuited rectifier. One low and one high resistance reading will show that the rectifier is functioning as a rectifier. It will not, however, show whether the forward resistance is sufficiently low or the reverse resistance sufficiently high for satisfactory performance.

6. *Forward Current Test*

Figure 1 shows a simple circuit which can be made for testing the forward resistance of a selenium rectifier. The limits of forward current for each type of rectifier are shown in Table 1. These figures are approximate and give a good indication as to whether the rectifier is near the end of its useful life. There will be cases where rectifiers tested to these limits will not give high enough B+ voltage. Judgment must be used in marginal cases by testing the rectifier in the set and measuring the B+ voltage under actual working conditions. A rectifier which produces B+ voltage near the operating limit may cause trouble in the near future.

7. *Reverse Current Test*

Figure 2 shows a simple circuit which can be made for testing the reverse current of a selenium rectifier. When voltage is first applied to a good rectifier the reverse current will be high and will rapidly decrease while the voltage is applied. The short circuiting switch is used to protect the meter during the high current or forming period. Allow 1½ to 2 minutes for forming. It would be desirable to use a variable voltage transformer or a potentiometer (as shown) to increase the voltage gradually, protecting the tube in the event the rectifier has low reverse resistance.

TEST CIRCUITS

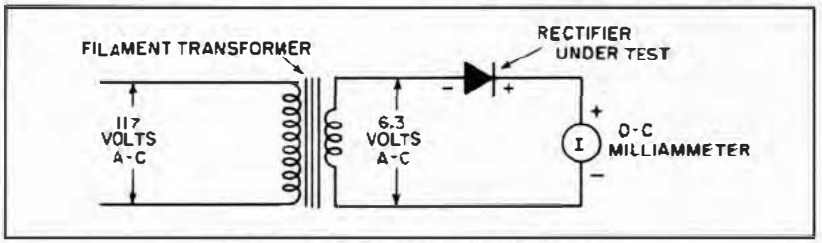


FIG. 1 FORWARD CURRENT TEST

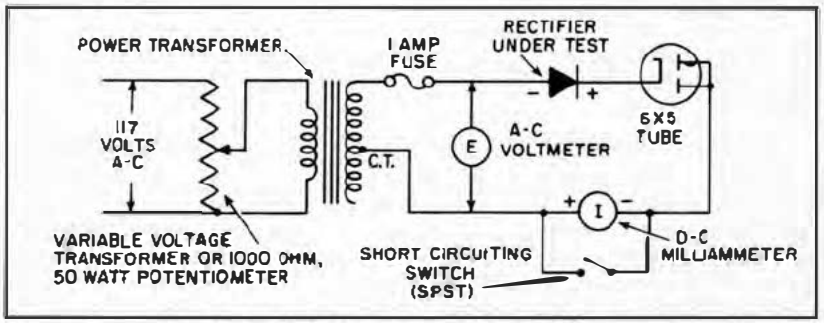


FIG. 2 REVERSE CURRENT TEST

TROUBLE SHOOTING CHART

Trouble	*Possible Condition*	*Procedure*
No B+ voltage.	Open line resistor. Open rectifier.	Test for AC voltage between switch and B—. If o.k.: Test for AC voltage between rectifier + and B—. If o.k. check stack for open circuit.
Low B+ voltage.	High forward resistance rectifier. Leaky or low capacity condenser. Excessive B+ current.	Test rectifier for forward resistance. If o.k.: Test condenser for capacity and leakage. Test B+ circuit for excessive tube current or partial short circuit due to defective components.
Hum in Loudspeaker.	Leaky or low capacity condenser. Low reverse resistance rectifier.	Test condenser. If o.k.: test rectifier.
Sparking or dark spots on plates of rectifier.	Deformed rectifier.	If sparking occurs after set has been inoperative for a long time, leave it on as rectifier will probably reform. If sparking continues, test rectifier reverse resistance. If reverse current is high or sparking persists, replace rectifier.
Burned out line resistor.	Defective condenser. Defective rectifier. Shorted load.	Test for shorted rectifier or condenser. Check load for excess current or intermittent shorts.

Table I—TEST LIMITS for FEDERAL SELENIUM RECTIFIERS

Rectfier Model Number	*Forward Current Test Minimum Milliamperes at 6.3 Volts A-C (See Fig. 1, Page 70)*	*Reverse Current Test Maximum Milliamperes at E=240 Volts A-C (See Fig. 2, Page 70)*
1002	20	13
1003	20	13
1004	33	19
1005	33	19
1006	80	23
1007	11*	6*
1008	19*	8*
1009	43*	10*
1010	80	23
1014	19	8
1021	135	31
1022	65	13
1023	120	27
1028	80	23
1090	80	23
1101	20	13
1159	6	4
1200	210	48
1214	12	8
1223	210	48

* Test Limits Apply to a Single Section.

Federal SELENIUM RECTIFIER REPLACEMENT KITS

Federal has assembled—in two separate packages—all the selenium rectifiers used in 90 per cent of television and radio replacements. Television and radio servicemen can provide satisfactory replacements *on the spot* by keeping these kits handy. They are also an excellent laboratory aid. They're available through authorized Federal Distributors.

KIT #1

For Television Selenium Rectifier Replacement

Kit #1 contains two each of these four "preferred types":

Type	*Maximum Ratings*
FTR 1004 A	(100 Ma—130 volts)
FTR 1028 A	(250 Ma—130 volts)
FTR 1023	(350 Ma—130 volts)
FTR 1021	(450 Ma—130 volts)

KIT #2

For Radio Selenium Rectifier Replacement

Kit #2 contains two each of these four "preferred types":

Type	*Maximum Ratiags*
FTR 1002 A	(65 Ma—130 volts)
FTR 1003 A	(75 Ma—130 volts)
FTR 1004 A	(100 Ma—130 volts)
FTR 1005 A	(150 Ma—130 volts)

SECTION III

Other *Federal* SELENIUM RECTIFIER PRODUCTS

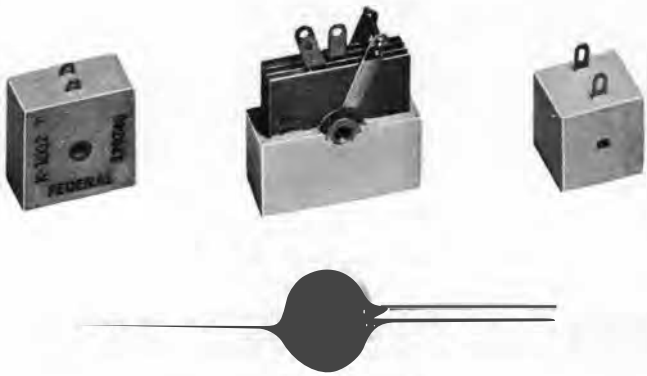
This section describes several of the product applications of Federal selenium rectifiers that may be of interest to the reader, including the following:

- **Encapsulation of Selenium Rectifiers**
- **High Voltage Selenium Rectifiers**
- **Contact Protection**
- **Selenium Diodes**
- **"Packaged Power" Rectifiers**
- **Assembly Kit**

APPLICATIONS

Among the many applications of Federal selenium rectifiers are: Battery chargers for automobile, railroad, signal, telephone, and industrial trucks; Power supplies for arc welding, aviation equipment, beacons and beam transmissions; burglar alarms, business machines, carrier and high frequency controls, magnetic chucks, brakes, clutches, relays and radio remote controls; Special applications for electrolysis, drain for static charges, polarizer for signaling on a-c circuits, spark quenchers, etc.

Federal New Encapsulation Process for Selenium Rectifiers and Other Assemblies



APPLICATION

Federal's encapsulation process is a means for embedding selenium rectifiers and allied components in a special protective sealing as shown in the photograph. This permits operation of these components over wide temperature ranges (—65°C to +125°C) and virtually eliminates failure due to accumulation of dust, condensation, acid vapors, fungus, and other destructive elements. This process is of particular interest to military and airborne equipment designers where it is necessary to meet rigid specifications covering extreme temperature, weather, and storage conditions. For further information write for Federal booklet on encapsulation.

CHARACTERISTICS

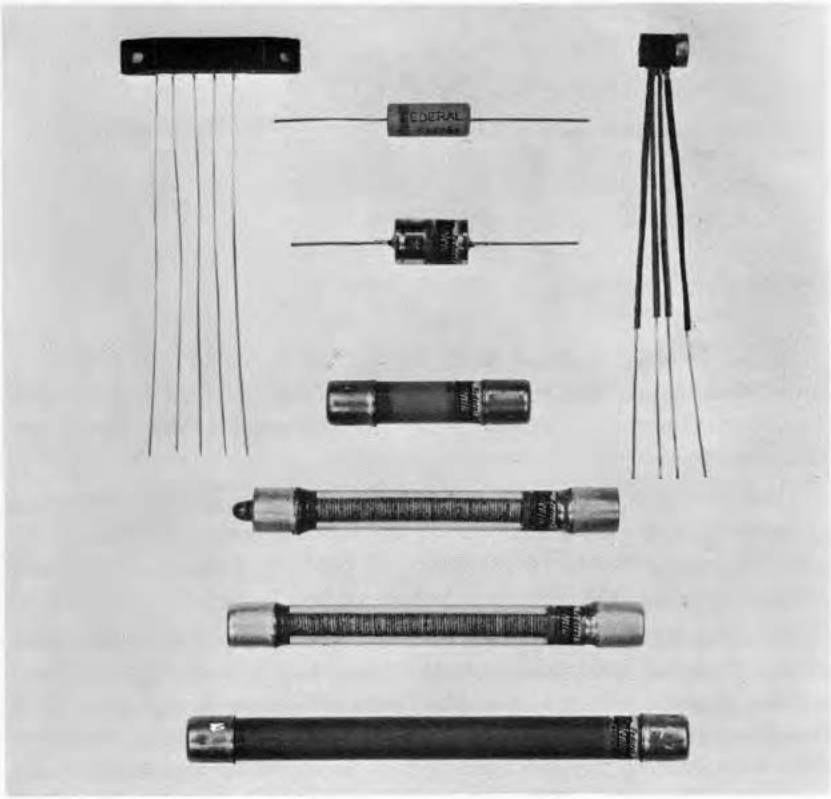
Mechanical Properties

1. High coefficient of expansion, thermal shock, and tensile strength.
2. Embedments withstand an ambient temperature range of —65°C to +125°C.
3. Weight increases only by a factor of 1.25 to 3.5 times the weight of original stack.
4. Studs or bushings for direct mounting can be incorporated as part of unit.

Electrical Properties

1. Maximum resistance to moisture, salt spray, solvents, fungus, etc.
2. Flashover value of 300 volts per mil, compared to 30 volts for air.
3. Thermal conductivity—.0045 to .008 watts /CM^3/°C.

Federal HIGH VOLTAGE
SELENIUM RECTIFIERS



CIRCUIT APPLICATION

Federal's high voltage, enclosed selenium rectifiers—with voltage ratings from 250 volts to 5000 volts and current ratings of 20 ma for half-wave circuits and 40 ma for full-wave circuits—have found wide application in photo-flash power supplies, cathode ray oscilloscopes, television circuits, d-c power supplies, high voltage testing equipment, bias supplies, and many other high voltage, low current circuits. These rectifiers are available in a fiber enclosure; in an hermetically sealed glass enclosure for operation at high temperature and humidity; in plastic enclosures for application in full-wave and doubler circuits with voltage rating of 26 to 500 volts RMS; and in encapsulated paper tubes with extending pigtails in applications where encapsulation is desirable. (See page 74.)

For further information about high voltage selenium rectifiers write to Federal for a complete booklet.

CONTACT PROTECTORS

Federal offers selenium rectifiers for use in contact protection, a unique development that gives promise of solving the annoying problem of destructive arcing at contact points in stepping switches, relays and other devices.

Federal's new Contact Protector has a minimum effect on the speed of operation of the associated circuit while giving good protection to the controlling contacts. It is dependable and needs no attention. It is easily installed, requires little space and is low in cost.

Investigation has shown that Federal's Contact Protector will accommodate all signal and telephone type relays which operate up to 40 times per second and draw up to 600 Ma operation current at 150 volts, D-C. These have run well over 100 million operations with no sign of failure of the Contact Protector and indicate that the life of the protected contacts may be extended 20 to 100 times that of unprotected contacts with coincident minimizing of RF interference.

The size and type of the selenium Contact Protector is determined by the energy dissipation requirements and operating conditions of temperature and humidity. The energy to be dissipated is related to the inductance and resistance of the protected circuit, the number of operations per second and the supply voltage. For the most economical and effective unit for your requirements, information as requested below should be submitted to Federal's application engineers:

1. Operating voltage and current; 2. Type of Contact; 3. Number of operations per second; 4. Speed of response required; 5. Unusual atmospheric conditions (temperature, contamination, high-moisture, etc.); 6. If possible, measure of inductance or number of ampere-turns of coil whose circuit is being broken by contacts to be protected.

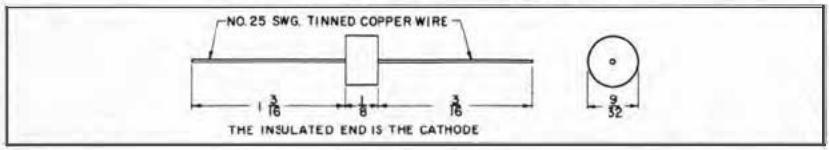
Federal 1215

SELENIUM DIODE

AVERAGE ELECTRICAL CHARACTERISTICS

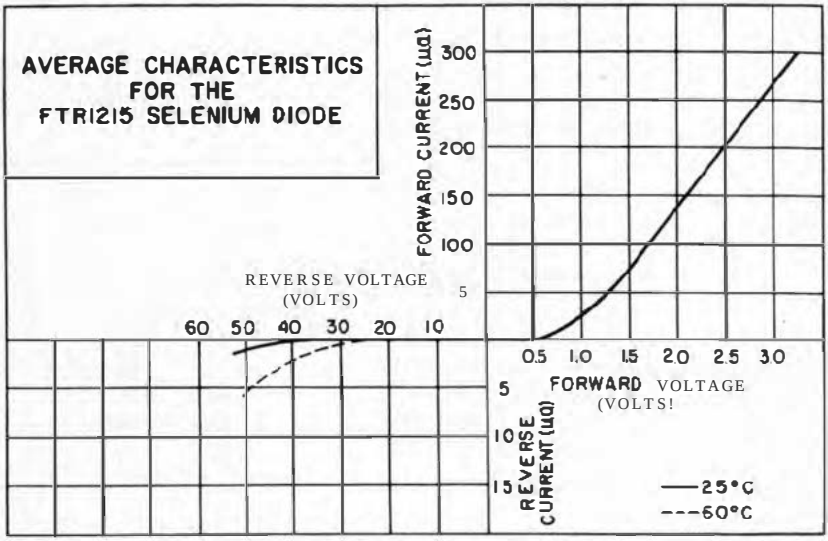
Rated Forward Current, Max.	250 microamp.
Peak Current, Max.	2.5 ma
Forward Current at +2 volts	100 microamp.
Peak Inverse Voltage, Min.	—50 volts
Continuous Inverse Voltage, Max.	—30 volts
RMS Input Voltage (res. load) Max.	36 volts
Reverse Current at —40 volts, Max.	2 microamp.
Ambient Temperature Range (°C)	—50 to +60
Shunt Capacitance at 200 kc.	20 mmf
Frequency, Max.	5 mc

DIMENSIONAL DIAGRAM



APPLICATION

The Federal 1215 Selenium Diode can be used to best advantage in low-level applications such as AGC, switching circuits, blocking, bias supplies, detectors, clippers, limiters, and AFC circuits. A typical characteristic curve for this selenium diode is shown below.



Federal

PACKAGED POWER
SELENIUM RECTIFIER STACKS

Federal has America's largest stock of stacks for all popular applications . . . available through your nearest distributor. The packaged list shown below is but a fraction of Federal's designs available for meeting any a-c to d-c power conversion need.

Max. D.C. Output (Approximate)‡		Rectifier Stack Code	Max. A.C. Input	Rectifier Stack Dimensions		Catalog
Volts	Amps	Number	Volts	A	B±1/16"	Number
10	3.0	106C1AX1	13	3 3/8"	1 9/16"	2100
	6.0	133C1AX1	13	4 3/8"	1 3/4"	2101
	12.0	136C1AX1	13	5" x 6"	1 3/4"	2102
20	3.0	106B1AX1	26	3 3/8"	2 1/16"	2103
	6.0	133B1AX1	26	4 3/8"	2 1 1/16"	2104
	12.0	136B1AX1	26	5" x 6"	2 3/4"	2105
40	3.0	106B2AX1	52	3 3/8"	3 9/16"	2026
	6.0	133B2AX1	52	4 3/8"	5"	2107
	12.0	136B2AX1	52	5" x 6"	5 1/4"	2108
60	3.0	106B3AX1	78	3 3/8"	4 1/2"	2118
	6.0	133B3AX1	78	4 3/8"	6 3/4"	2033
	12.0	136B3AX1	78	5" x 6"	7 5/16"	2085
80	3.0	106B4AX1	104	3 3/8"	5 1/2"	2109
	6.0	133B4AX1	104	4 3/8"	8 9/16"	2110
	12.0	136B4AX1	104	5" x 6"	9 5/16"	2111
100	1.0	139B5AX1	130	2" Sq.	5 3/8"	2112
	2.4	106B5AX1	130	3 3/8"	6 5/8"	2113
	6.0	133B5AX1	130	4 3/8"	10 9/16"	2114
120	0.3	103B6AX1	156	1 9/32" x 1 13/64"	4 3/4"	2115
	0.6	104B6AX1	156	1 17/32" Sq.	4 7/8"	2036
	1.0	139B6AX1	156	2" Sq.	6 7/16"	2116
	2.4	106B6AX1	156	3 3/8"	7 5/8"	2038
	6.0	133B6AX1	156	4 3/8"	12 5/16"	2117

‡ Resistive or Inductive Loads

Federal
SELENIUM RECTIFIER
ASSEMBLY KIT

One of the latest innovations in the rectifier field is Federal's new Selenium Rectifier Assembly Kit. This kit enables radio hams, hobbyists, repairmen, electrical technicians and others in the electrical, radio and television fields to build their own rectifying equipment for a wide range of a-c to d-c applications.

Each kit contains all necessary components for assembling—at a saving—any one of four different types of selenium rectifiers. Instructions for assembly are enclosed in each kit.

The four types, with their D-C load voltage and Maximum Ampere Rating are:

1. *Half-Wave Rectifier.*

D-C Load Voltage: Since each cell is capable of operating at 18-volt a-c, the maximum voltage that can be impressed upon the a-c terminals is 8 x 18=144 volts, or roughly 140 volts. With capacitative or battery loads maximum a-c rating is 72 volts. The d-c load voltage at full load and with 140 volts a-c will be about 62 volts. With capacitative or battery load and 72 volt a-c applied the d-c voltage will be about 95 volts or less depending upon the size of the condenser.

Maximum Ampere Rating: With resistive or inductive load the maximum current which may be drawn is 5 amps. For battery charging or capacitative load the maximum current is 4 amps. for continuous duty.

2. *Full-Wave Center Tap Rectifier.*

D-C Load Voltage: The maximum d-c load voltage depends upon the maximum a-c voltage obtainable across the transformer secondary winding. Since there are four cells at 18 volts in each arm, the total inverse a-c voltage across the secondary winding is 72 volts. Due to the center-tapping, half of this amount is supplied in each half-cycle, so that 36 a-c volts are supplied at all times. If all losses are considered, the total d-c output will be about 28 volts.

Maximum Ampere Rating: For resistive and inductive loads—10 amps. For continuous battery charging or capacitative loads and motor loads use only 8 amps. When charging batteries with a taper charge the starting rate may be 10 amps.

3. *Full-Wave Bridge Rectifier.*

D-C Load Voltage: With an a-c input voltage of 36 volts and a current load of 10 amps., the output voltage will approximate 26 volts.

Maximum Ampere Rating: For resistive and inductive loads—10 amps. For taper charging the starting rate may be 10 amps. For constant current charging or capacitative loads and motor loads—8 amps.

4. *Full-Wave Battery Charger.*

D-C Load Voltage: The a-c voltage during each half-cycle is supplied alternately by the upper and lower halves of the center-tapped transformer winding. Since both halves of the winding must supply a-c voltage, the total a-c voltage across the entire transformer winding must be more than twice the d-c voltage needed for charging.

Maximum Ampere Rating: For taper charging the starting rate is 10 amps.; for constant current charging—8 amps.

Selenium Rectifier Assembly Kits are sold only through authorized Federal distributors.

New all-purpose Selenium Rectifier Assembly Kit, a product of Federal Telephone and Radio Company, Clifton, N. J., a division of International Telephone and Telegraph Corporation. The kit enables hams, hobbyists, experimenters, and professionals in the electrical, radio, and television fields to build any one of 24 variations of four rectifier types —Half-wave, Full-wave Center-tap, and Full-wave bridge—including Full-wave battery charger. The kit contains eight 5" x 5" plates, plus all necessary hardware. Every assembly step is clearly explained by easy-to-follow diagrams and text.