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GE Electronic TUBES
Techni-talk on AM, FM, TV Servicing
Vol. 4

TV RECEIVER NOISE

In the early days of radio broadcasting, when it was often necessary to listen to stations some distance away, and even today in country locations far removed from powerful stations, the one factor above all else which prevented the fullest enjoyment of this medium of entertainment was atmospheric noise or static. Today with the advent of television broadcasting on the higher frequencies, static is no longer a problem. The reason for this is that atmospheric noise contains very little radio frequency energy above approximately 30 mc in frequency. For this, of course, we are thankful but unfortunately all the problems of distant and weak signal reception of TV stations are not solved by the absence of static. It is all too apparent to those of us who receive weak TV signals due to location that in addition to the desired signal our screen also shows an abundance of what is popularly called "snow." Fig. 1 shows the effect of "snow" on a test pattern.

This snow is of course unwanted noise, just as static is, but it is of different origin. It is not caused by atmospheric disturbances but rather by disturbances in the receiver and antenna system. It existed in our broadcast receivers but usually was masked by the static in the atmosphere and so was of little or no concern.

Let's see what causes this noise and what can be done to overcome it or at least make it low enough to let us enjoy the weaker TV stations. This noise may be broken down into two different sources. These are called the "shot" noise and the "thermal-agitation" noise or as it is sometimes called the Johnson noise or Shottky effect. The "shot" noise is produced in all vacuum tubes and is caused by the fact that electrons leave the cathode at a random rate. In other words, the flow of electrons from the cathode to the plate of a vacuum tube is not a smooth steady flow, but one in which there are many minute variations in quantity. This variation in electron flow causes a minute variation in the plate current of the tube, and as far as the receiver is concerned it looks just like the variation in plate current caused by a signal. Since, however, it occurs at a random rate the end result is a random signal or as it appears on our screen it is called snow. This "shot" noise is present in all tubes, even diodes.

The noise generated in a tube increases as the number of elements in the tube is increased. Thus a tetrode or pentode generates more noise within itself than does a triode.

The second source of noise, "thermal-agitation," is caused by the movement of electrons in a conductor or resistor. At any temperature except absolute zero the electrons in a conductor are in constant and random motion. It follows that at any given instant there may be more electrons at one end of the conductor than at the other, which is another way of saying that a voltage exists across the conductor. Since again it is a random effect it shows up in our receiver output as noise or snow. This "thermal-agitation" noise is dependent upon the temperature above absolute zero, but for all practical receiver conditions we need not worry about this temperature effect. In other words don't go putting your TV receiver in the refrigerator, it probably won't make any noticeable difference in the snow. This noise, like static, is produced over a very wide range of frequencies, and the amount of noise in the output of the receiver from this source is dependent on the band width of the receiver.

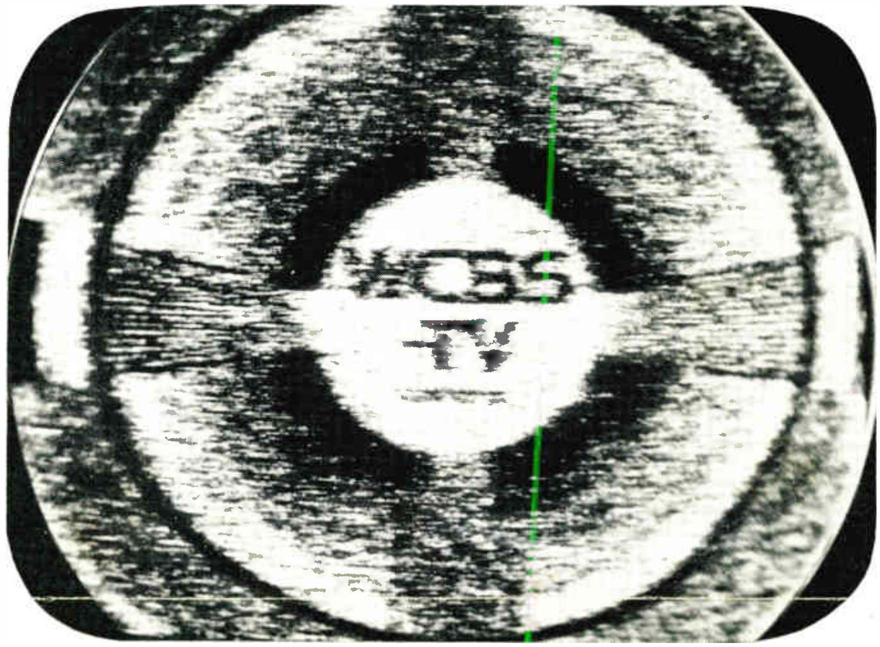

Fig. 1. Test pattern showing the presence of a considerable amount of "snow." This photograph was taken in Schenectady, New York which is some 160 miles from the WCBS transmitter located in New York City.

This "thermal-agitation" noise present in all conductors is also present in the antenna system; and it can be shown to be equal in value to the noise produced by a resistor equal in ohmic value to the radiation resistance of the antenna in question. Thus a folded dipole with a radiation resistance of 300 ohms produces the same noise as a resistor of 300 ohms, and a straight dipole of 72 ohms radiation resistance produces the same noise as a 72-ohm resistor.

Now that we have briefly explained the causes and sources of noise in a receiver, it is possible for us to set down a few basic facts about TV receivers that may help to clear up this question as to what produces the snow. First of all we have the noise generated by the antenna itself, and if we had an otherwise perfect receiver this antenna noise would still be present in the receiver's output. Since we can't at present do without an antenna this much noise or snow will have to remain. Next comes the first stage in the receiver, usually an R-F amplifier stage, and it is this stage (or possibly the first two stages) that determines whether the receiver is good or bad in regard to noise output. As shown previously this first tube will generate a certain amount of "shot" noise, and this noise will be amplified along with the signal by all the rest of the stages in the receiver. So it is easily seen that the less the noise generated by this first stage, the less noise there will be in the output of the receiver. This statement assumes that the first stage in the receiver has sufficient amplification so that the noise generated by the second stage will be but a small percentage of the output from the first stage. If the gain of the first stage is low it then becomes necessary to make the second stage a low noise generating stage also.

Since the noise generated in the first r-f stage passes through more stages of amplification than

	Antenna Terminals	Output of 1st stage	Output of 2nd stage	Output of 3rd stage	Output of 4th stage
Units of Signal	10	100	1000	10000	100000
Units of Noise	1	10+10=20	200+10=210	2100+10=2110	21100+10=21110
Total Per Cent Noise	10	20.0	21.0	21.1	21.11
Units of Signal	10	100	1000	10000	100000
Units of Noise	1	10+5=15	150+10=160	1600+10=1610	16100+10=16110
Total Per Cent Noise	10	15	16	16.1	16.11

Fig. 2. Table illustrating that the amount of noise present at the output of the first stage represents the greatest percentage of noise or "snow" seen on the picture tube. In the top section each stage develops ten units of noise and in the bottom section the noise generated in the first stage is reduced fifty percent.

No. 1

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that generated in any other stage, it is important that the amount of noise produced in this circuit should be kept as low as possible. Each succeeding stage amplifies the noise present at its input but in addition adds to it the noise produced in that stage. The TV signal however is only amplified in the same proportion as the noise is amplified but no additional signal is picked up to offset the noise added by each stage. It can be seen that the proportion of noise increases as the signal passes through each succeeding stage. The amount of noise added by each stage, however, becomes less important since it is amplified by fewer stages.

A very simple hypothetical example illustrating this is shown in Fig. 2. Let us assume that ten units of signal is present at the input of a receiver together with one unit of noise. Let us also assume that the gain of each stage is ten and that each stage contributes ten units of noise. The top section of the table in Fig. 2 illustrates that even though each stage adds the same number of units of noise the greatest increase in percent of noise occurs at the output of the first stage. The increase in the second stage is significant but to a much lesser degree than the first stage. The following stages contribute such a small increase that for all practical purposes they can be disregarded.

Since the greatest increase in the percent of noise occurs at the output of the first stage any reduction in the noise generated here will be many times more effective than a noise reduction in any other stage. If, for instance, the noise developed in the first stage of the top section of Fig. 2 could be reduced by 50 percent the total percent of noise at the output of the first stage would be reduced five percent as shown in the lower section of Fig. 2. This is almost five times the total amount of noise produced in the second, third and fourth stages combined. It follows, therefore, that a 50 percent reduction of the noise in the first stage would result in a total reduction almost five times as great as *completely* eliminating the noise in all the other stages combined. This is significant because any reduction in the amount of noise generated in the first stage should result in a noticeable decrease in the noise at the input to the picture tube.

Reception on television receivers used in weak signal areas can be improved in two ways. First, the antenna system should be the best possible in order to achieve maximum signal pickup. It is beyond the scope of this discussion to recommend any type of antenna but assuming that we have the best practical system the next step is the installation of a booster amplifier.

Two types of booster amplifiers have made their appearance on the market. One type is used ahead of the TV receiver and the other type is inserted in the I-F amplifier and consists of an additional stage of I-F amplification. A simple test will determine which of these two types will give improved reception. If, with the contrast control full on, the picture is fair but lacks contrast and appears washed out, the receiver does not have sufficient amplification and the I-F booster may furnish the additional gain necessary. This type will not improve the noise characteristic of the receiver in any way and should only be used on receivers having satisfactory noise level. One additional word of caution concerning this type of booster is that it may cause the I-F amplifier of the receiver to oscillate due to the increased gain and unavoidable changes in circuitry.

The other type of booster amplifier, and by far the more popular type, consists of additional R-F amplification to be used between the antenna and the receiver. With this type of booster it is possible to both increase the over-all amplification of the receiver and to improve the noise characteristic. If the receiver already has sufficient over-all amplification as shown by the test just described, then the only advantage of the booster is to reduce the snow or noise output. To accomplish this the booster must generate in itself less noise than is generated in the first stage of the receiver and must have sufficient gain to fulfill the conditions described previously and shown in the example in Fig. 2. If this is not the case no advantages will be realized by the use of a booster amplifier.

At this point it might be well to define the term "noise figure" which is presently being used as a figure of merit for receivers. As stated previously the lowest possible noise is determined by the antenna noise if we are considering a perfectly noise-free receiver. The noise figure of a particular receiver is then the noise output of the receiver plus the noise output contributed by the antenna divided by the noise output caused by the antenna. Stated another way, we can say that the noise figure is the power ratio of the noise in a particular receiver compared with the noise in a perfect receiver when all things such as bandwidth and input impedance are equal. This power ratio is usually expressed in decibels or db and a receiver having a noise figure of 10 db would have 10 times the noise output of a perfect receiver, and a receiver having a noise figure of 6 db would have 4 times the noise output. As far as our picture is concerned a decrease in the noise figure of 3 db is equivalent to increasing the signal received from the TV station two times. Unfortunately there is not much that we as service technicians can do to improve any particular receiver's noise figure. This is a problem for the design engineer. and as is to be expected, they are constantly improving the noise figures of receivers by developing new circuit techniques and new low noise R-F amplifier tubes. Practically all of today's TV receivers use triodes or triode-connected tetrodes or pentodes as R-F amplifiers. These tubes are used either in grounded-grid, neutralized or in "cascode" type circuits. Receivers having two RF stages should be superior to those receivers having but a single R-F stage ahead of the mixer. One obvious reason for this is that the front-end will have more gain. Another very good reason is that mixer tubes are more noisy than the same tube employed as an amplifier.

Accordingly, as stated before, it is necessary to build the noise and signal of the first stage or stages up to a sufficiently high level so that the noise generated by the mixer is but a very small percentage of the total. One stage of grounded-grid R-F amplification is not ordinarily sufficient to do this.

Among the new tube types recently developed for low noise front-ends and boosters are the 6BK7 and 6BQ7 tubes. These are designed to be used in the cascode circuit, and their inclusion in a receiver or booster is an excellent indication that every effort has been made to produce a unit which will operate satisfactorily in fringe areas. Of course circuitry and layout are also a factor in low noise design so that the mere fact that tubes of this type are included is not 100 percent insurance of a good receiver. If possible, get data on the actual noise figure of the receiver and compare it with others when looking for one to be used for fringe area reception.

CONVERSIONS—MOTOROLA 12VT16 TO 16 INCH

This is the eighth of a series of articles on converting TV receivers to use larger picture tubes. In this issue a Motorola Model 12VT16 was converted from a twelve-inch round to a sixteen-inch rectangular picture tube.

The following discussion is a description of the procedure followed which produced satisfactory results with respect to the particular model converted. If a conversion is attempted on a similar model of an earlier or later date or on a different model from the same manufacturer, then additional adjustments and steps may be necessary. The changes which were made have not been approved by the manufacturer and may therefore invalidate the manufacturer's warranty.

The Motorola Model 12VT16 shown in Fig. 1 was originally a twelve-inch receiver. This was converted to use a General Electric 16KP4-A picture tube which was the largest size that could be used without a considerable amount of cabinet work. Practically the same chassis was used in models VT121 and 12VK18; therefore, the same circuit changes should also produce satisfactory results on these models.

The following parts were required to make this conversion:

1—General Electric 16KP4-A picture tube.
1—General Electric 6S4 tube.
1—General Electric RET-003 ion trap magnet.
1—Stancor A-8129 horizontal sweep transformer or equivalent.
1—Stancor DY-8 deflection yoke or equivalent.
1—9 pin miniature socket.
1—1627R sixteen-inch light Royalite plastic mask measuring 14 in. x 18 in. This mask must be used in back of a piece of safety glass. (Manufactured by Precision Plastics, Inc. in Chicago and represented by the Hy-Art Co., 136 Liberty St., New York, New York.)
1—12 in. x 16¾ in. x $\frac{7}{32}$ in. piece of safety glass.

List prices of the foregoing parts, at date of publication, totaled $74.75. However, allowance should be made for any local differences due to transportation costs, etc.

CHASSIS CHANGES

The chassis was removed from the cabinet and the following circuit changes were made:

1. The original deflection yoke was removed and replaced with a Stancor DY-8. The 68 mmf capacitor, which was connected across one of the horizontal coils, and the two 560 ohm resistors, which were connected across the vertical coils, were removed from the original yoke and used on the new deflection yoke.
2. The original horizontal sweep transformer was removed and replaced with a Stancor A-8129 and wired as shown in Fig. 3. The 3.3 ohm resistor R-117 in the filament lead to the 1B3-GT high voltage rectifier was removed.
3. The capacitor can containing C-89 A, B, C and D was removed from the top of the chassis and remounted in the same hole below the chassis. It was only necessary to disconnect the wires and straighten the B— lugs in order to make this change. The insulator plate was not disturbed. This

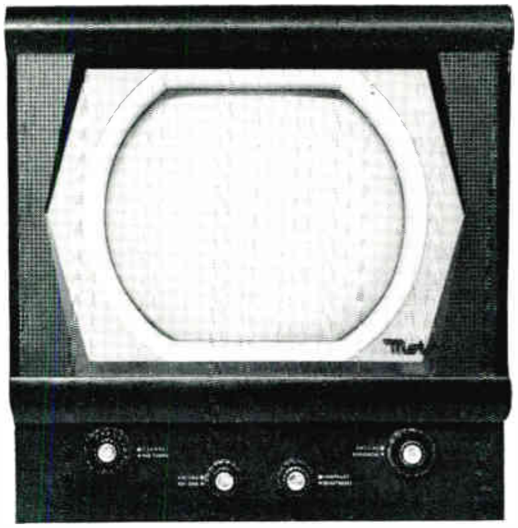


Fig. 1. Motorola twelve-inch Model 12VT16 before conversion.

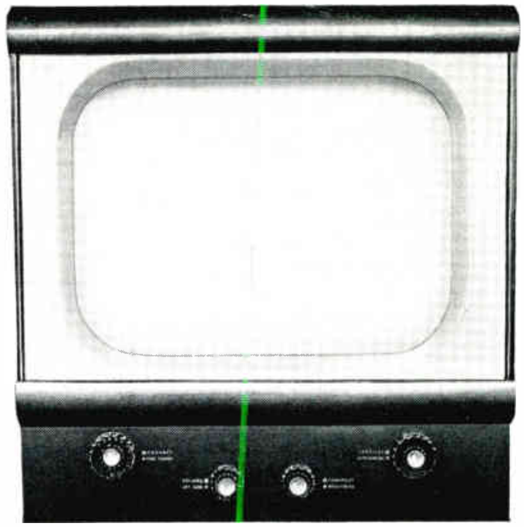


Fig. 2. Motorola Model 12VT16 after it had been converted to use a General Electric 16KP4-A picture tube.

change was necessary since this capacitor interfered with the bell of the new picture tube.

4. The deflection yoke and focus coil mounting bracket was moved toward the back of the chassis as far as possible. It was not necessary to drill any new holes since there was a considerable range over which this bracket could be moved.
5. The original picture tube was held in place by a felt lined metal band around the perimeter of the faceplate. The left side of this metal band was bent so that it was about one-half inch above the top of the chassis. The right side was cut off and bent the same as the left side to provide a support for the bottom of the 16KP4-A faceplate. A piece of metal hanger strap similar to that used on antenna chimney mounts was used to hold the front of the picture tube in place. This was fastened to each side of the chassis with self-tapping screws. Two three-inch pieces of one-inch wide sponge rubber were used between the top corners of the picture tube and the hanger strap to prevent slipping and to absorb shock. A separate six-inch piece of hanger strap was fastened to the top of the metal strap with a screw and nut and bent to contact the graphite coating on the bell of the picture tube.
6. A 6S4 9-pin miniature was used as a separate vertical output tube, and mounted near the 6SN7-GT which was used as a combination vertical blocking oscillator and output tube. The connections to pins 1, 2 and 3 on the 6SN7-GT V-15 were removed and connected to the 6S4 tube as shown in Fig 4. The filament of the 6S4 was connected in parallel with the other 6.3 volt filaments.
7. The new General Electric RET-003 single magnet ion trap was placed on the neck of the picture tube and adjusted for maximum brightness.
8. The focus control operated very close to the end of its range and in some cases it might be necessary to replace the focus coil with a permanent magnet type similar to the Quam QF-2 focalizer.
9. The width, height and linearity controls were adjusted to produce a linear test pattern.

CABINET CHANGES

The following cabinet changes were then made:

1. The four screws located inside the cabinet just above the control shaft openings were removed. This loosened the wooden panel which held the safety glass and rubber mask in place.
2. The original safety glass and mask were removed and discarded. A new piece of safety glass 12 in. x 16 ¾ in x $\frac{7}{32}$ in. was purchased from a local glass company. The outside edges of the new plastic mask was cut down to the same size as the safety glass. This type mask is so thin that it can be cut with an ordinary pair of scissors. The mask and the safety glass were then placed into the original opening and the wooden panel fastened in place as can be seen in Fig. 2.
3. The two wooden blocks which were fastened to the inside of the top of the cabinet were removed and discarded. Since these blocks were held in place with both glue and wood screws they were removed with a wood chisel and hammer after taking out the wood screws.
4. The chassis was put back into the cabinet and the screws, bolts, knobs etc. replaced. The completed conversion is shown in Fig. 2.

While these circuit modifications have been carefully tested, the General Electric Company can, of course, assume no responsibility for the application of these suggestions to the conversion of any particular receiver. General Electric offers this article as a suggestion of one possible way of making the conversion, but it does not represent that this is the only way or the best way of accomplishing the conversion.

In the next issue conversion information on another television receiver will be included.

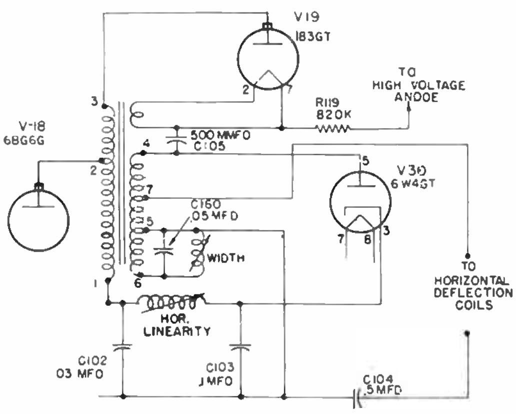


Fig. 3. Horizontal sweep output circuit after the output transformer had been replaced.

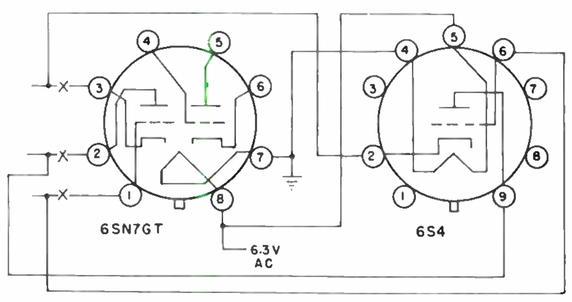


Fig. 4. Wiring changes made to use a 6S4 tube in place of one-half of the 6SN7-GT as vertical output tube. "X" indicates that the connection was permanently removed.

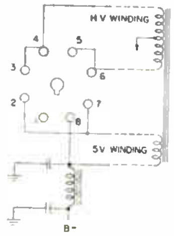
BENCH NOTES

Contributions to this column are solicited. For each question, short-cut or chronic-trouble note selected for publication, you will receive $10.00 worth of electronic tubes. In the event of duplicate or similar items, selection will be made by the editor and his decision will be final. The Company shall have the right without obligation beyond the above to publish and use any suggestion submitted to this column. Send contributions to The Editor, Techni-talk, Tube Department, General Electric Company, Schenectady 5, N. Y.

INTERCHANGEABLE RECTIFIER SOCKET

Here is a suggested method of wiring the rectifier socket so that it will take any one of the following types of tubes: 5T4, 5U4-G, 5V4-G, 5W4, 5X4-G, 5Y3-GT, 5Y4-G or 5Z4, or an 0Z4.

Tie pin No. 3 to No. 4.
Tie pin No. 5 to No. 6
Tie pin No. 2 to No. 7



Rudolf F. Graf
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Brooklyn 11, N. Y.

EDITOR'S NOTE: When making rectifier substitutions be sure that the filament current is the same, or lower, and more important that the plate current rating of the substitution is not lower than the original tube.

ALIGNMENT TOOL

This is a simple and practical solution to the long fiber, non-metallic screw driver needed for adjusting the oscillator slugs from the front of the channel selector switch. The screw driver is made from a ten-inch 1/8-in. diameter plastic knitting needle. The ends are cut off and filed to a screw driver point. This screw driver can be used where any non-metallic screw driver is needed in adjusting TV sets.

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Lewisdale
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SYNC TROUBLE-MOTOROLA 17T3

A Motorola 17T3 television receiver displayed the following symptoms: The set operated normally for approximately 15 minutes after being turned on. After this time the picture began gradually to tear horizontally, slowly getting worse and shortly after, losing both horizontal and vertical sync. This appeared similar to Tele-Clue K101. The trouble was located and cured by replacing the 6800-ohm resistor across the grid circuit of the 6CB6 tube in the last video i-f stage. This resistor was replaced with a 5000-ohm one-half watt resistor. The reduced value of this resistor apparently did not affect the gain of the receiver.

It was interesting to note that the original resistor did not change in value even when the receiver lost sync. Apparently the tube input capacity changed enough from its cold to hot condition to cause oscillation. After the set had lost sync it could be restored to normal operation by placing one's finger on the grid connection. A change in lead dress did not stop the oscillation.

Not all of the above models have a 6CB6 tube in the last i-f stage. Some have a 6AG5. The above trouble has been noted only in those models using the 6CB6 tube.

Gordon S. Knaier, Sr.
68 Halbert Street
Buffalo 11, New York

ELUSIVE SOUND VARIATIONS

I was recently called upon to repair two R.C.A. TV receivers, Models TC167 and 6T87, with the complaint of occasional diminution of volume and consequent blaring of the sound when the volume control is adjusted.

In both cases conventional trouble shooting methods on the complete audio system failed to reveal any defect.

Although no outward sign of video or synchronization failure was noticed or complained of by the customer, I finally in desperation checked these circuits and in each set found a very weak sync separator tube. After replacement of the 6SN7-GT (V108 in TC167) and the 12AU7 (V107 in 6T87) the sound returned to normal without further fluctuation.

Philip Mentle
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Bronx 68, New York

What's new!

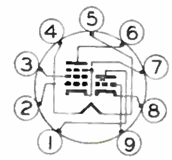
6U8

The 6U8 is a miniature triode-pentode designed primarily for use as a combined triode oscillator and pentode mixer in television and FM receivers. Each section has a separate cathode and is electrically independent. The tube is capable of good performance at the higher frequencies and may be used in a variety of combined functions.

Heater Voltage (A-c or D-c) . . . . . . 6.3 Volts
Heater Current . . . . 0.45 Ampere

CHARACTERISTICS AND TYPICAL OPERATION

	Triode Section	Pentode Section	
Plate Voltage	150	250	Volts
Screen Voltage	—	110	Volts
Cathode Bias Resistor	56	68	Ohms
Amplification Factor	40	—	
Plate Resistance (Approx.)	0.005	0.40	Megohm
Transconductance	8500	5200	Micromhos
Plate Current	18	10	Milliamperes
Screen Current	—	3.5	Milliamperes
Grid Number 1 Voltage (Approx) for Ib = 10 Microamperes	−12	−10	Volts



21EP4-A

The 21EP4-A is a magnetic-focus and magnetic-deflection, direct-view, all-glass picture tube for television applications. It provides a 13⅞- by 19⅛-inch picture. Features of this tube are an electron gun designed to be used with an external single-field ion-trap magnet and a high-quality neutral-density faceplate to increase picture contrast and detail under high ambient light conditions. The space-saving rectangular face has a cylindrical front surface which materially reduces specular reflection. An external conductive coating serves as a filter capacitor when grounded.

Over-all Length . . . . 23 + 3/8 Inches
Greatest Bulb Dimensions
Diagonal . . . . 21 7/32 + 3/16 Inches
Width . . . . 20 1/4 + 3/16 Inches

RECOMMENDED OPERATING CONDITIONS

Anode Voltage (Average Brightness = 15 Foot-Lamberts) . . . . 16,000 Volts
Grid—No. 2 Voltage . . . . 300 Volts
Grid—No. 1 Voltage . . . . −33 to −77 Volts
Focusing-coil Current (RTMA Coil No. 109 at 3¾ Inches) (approximate) . . . . . . 116 Milliamperes
Ion-trap Field Intensity, approximate (Single-field ion-trap magnet) . . . . 35 Gausses

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