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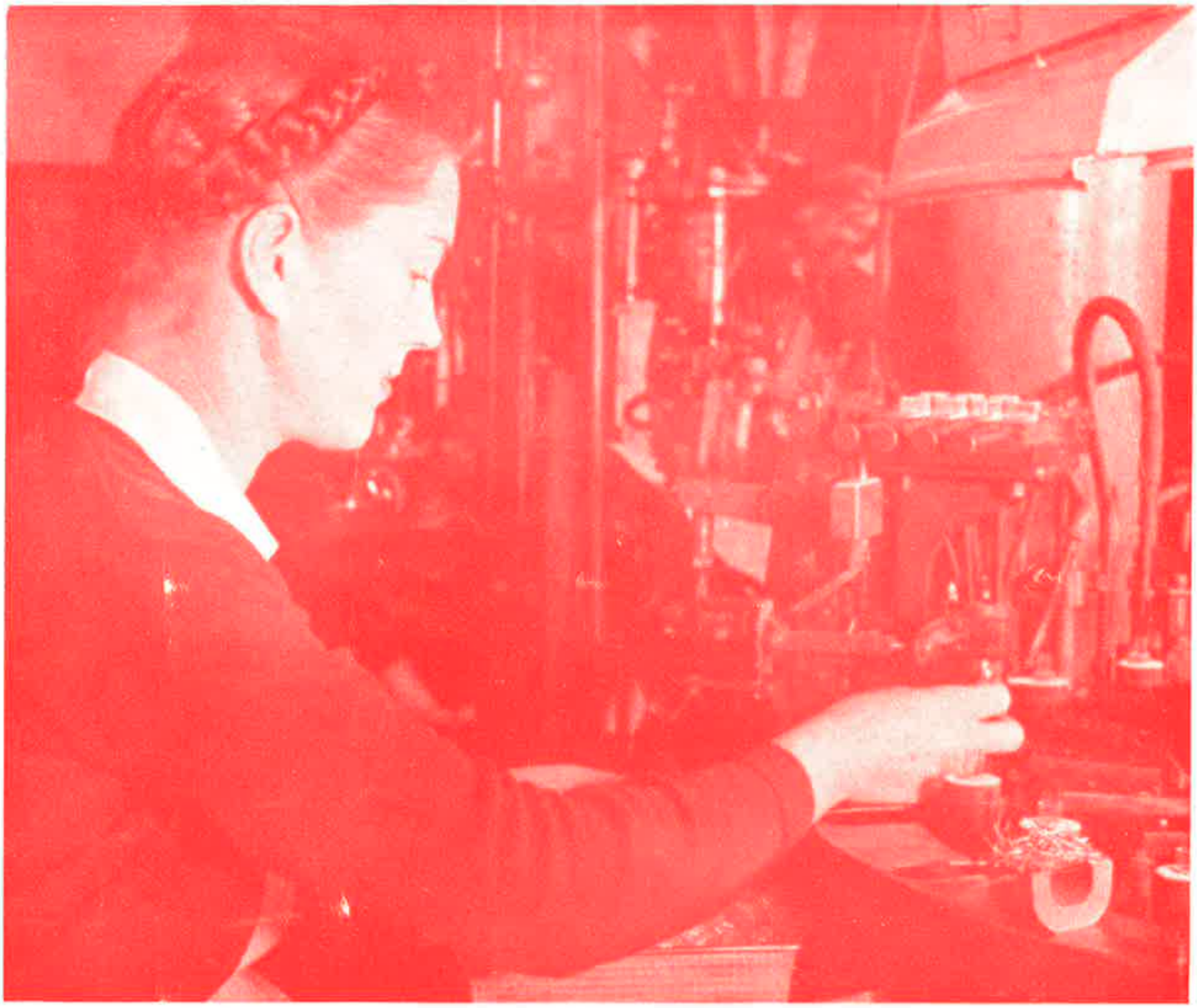
RADIOTRONICS

Volume 18 October, 1953 No. 10



A Miniature Button Base Making Machine In Action.

An AWV Publication

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RADIOTRONICS

Volume 18 **October 1953** **Number 10**

By the way—

SUBSCRIPTIONS FOR 1954 WILL NOT BE RECEIVED UNTIL ANNOUNCED IN A LATER ISSUE.

Our front cover this month is taken from the film "Australia Makes Radio Valves by the Million", and is reproduced here by courtesy of the Australian Diary Film Unit and shows a miniature button base making machine in action.

Revised data on numerous popular valves such as the 6AU6, 6BA6, and others appears in the latest edition of the Radiotron Valve Data Book, now on sale at technical booksellers and trade outlets for twelve shillings and sixpence.

Included for the first time is data on commonly used transmitting valves as well as phototubes and germanium diodes.

This new book replaces the earlier spiral bound edition, which is now obsolete.

New Zealand enquiries for the second edition should be directed to Amalgamated Wireless (Australasia) Ltd., P.O. Box 830, Wellington, or to any branch of National Electrical and Engineering Co. Ltd.

Information published herein concerning new RCA releases is intended for information only, and present or future Australian availability is not implied.

Issues of Radiotronics prior to March, 1953, are no longer available.

Editor:
Ian C. Hansen,
Member I.R.E. (U.S.A.)

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HI-HO FIDELITY

by Ed Wallace

Three months ago I met a man in a phonograph record shop who spoke a strange argle-bargle of sounds and whose eyes burned with a fierce crusading light.

It was my first experience with a hi-fi nut.

We were not complete strangers, since both of us work in the same office, but it is a large office and we had never exchanged words before. It was during the lunch hour and both of us were prowling the record shelves.

I pulled out a disk of *Gaite Parisienne,* began reading the back of the record sleeve, and almost instantly the man was at my side, smiling as people do when they know each other by sight but have never met.

"There is another recording of *Gaite* that is much better," the man said pleasantly. He whipped out the opposing label and handed it to me.

"More bass," he said. And as I recall now, he gave that word bass an ominous sound. I wasn't certain whether he considered more bass good or bad, nor at that time had my ears been pierced by "better highs", a term he used next in our conversation.

Reprinted through courtesy of HIGH FIDELITY magazine.

Glancing affectionately at the record of his choice, the man then asked me what I had to play it on. A more senseless question I had never heard. I glanced beyond the inquisitor, wondering suddenly if I wanted this chance meeting to flower into friendship or not.

"I plan to play it on a phonograph," I said.

I will never forget the expression of superiority, mingled with fatherly interest, which settled over this young man's face. I had encountered a man with a high fidelity music reproducing system. In less awesome terms, he owned a phonograph made up of individual parts and strung out all over the house. That, I learned later.

We talked for a few minutes in the record store. At least, *he* talked, and I became so confused that I delayed my decision on *Gaite Parisienne* until I could bring myself up to date. My new friend seemed more than willing to undertake my education in high fidelity and as we walked back to the office he poured out the first chapters of a story which I was to follow with considerable interest for a week.

We are both employed in the editorial department of a New York newspaper and between editions he would come to my desk and sit, face in hand, muttering statements about Bogen this and Scott that and McIntosh the other. He spoke of amps, damps and pre-amps until at the end of another week I wondered if, out of kindness, I shouldn't make the first move to have him committed to Bellevue for observation.

"Look," I said in some desperation one day, "I've got a dandy little phonograph that sits on a table and makes the grandest music you ever heard. I've never worried over it a minute."

"What kind of speaker does it have?" the man asked.

"How should I know what kind of speaker it has?" I demanded. "Inside, somewhere, I'm sure there must be a speaker. At least, the thing speaks!"

That noon he suggested we go to lunch together. We went, but we didn't eat. He, like a Judas goat, led me to a radio and television store where a neon-lighted arrow pointed up a stairway to a door identified as *Sound Studio.* We went in and the clerks greeted my friend in the warmest and most cordial terms.

"I come in here every day," he explained in answer to my surprise.

He spoke to a clerk while glancing casually at me, "This fellow wants to hear the Craftsman through an Electro-Voice Royal II and use the Pickering arm. Give him a switchover to the 604-B."

I had realized that my friend was an audio namedropper, but here he was outdoing himself. I hadn't the slightest idea what was going on, nor can I recall now that I was greatly impressed. A salesman began playing de Falla's *Three Cornered Hat* and my first impression was that here is music shot from guns. Notes began to pelt me from all directions, like puffed wheat. I looked over the amplifiers of various makes, having been assured that this was the heart of a high fidelity system, and I must say there is little excitement in this. An amplifier looks like a radio which didn't quite come off. When turned on, not connected to other units of a system, the amplifier is unable to utter a sound. I left the Sound Studio with a feeling of relief.

It was not until that evening when I played my dandy little phonograph at home that I realized it wasn't all it should be. A few days later I visited the Sound Studio of my own accord.

What follows is the case history of a convert to high fidelity. It is a review of the mental processes, aural awakening, decisions and indecisions, and the exciting journey from knowing nothing to knowing everything about high fidelity reproduction of recorded music in the home. Yes, everything. I have now paid my money, the living room is electronic beyond all belief, and I own more than a hundred long playing records. I am one of the boys, and I am entitled to speak. I have yet to find a hi-fi nut who doesn't radiate authority and advice and I propose to be no exception.

Among my new friends I number a gent who has seventeen loudspeakers in his home and, while I laugh at him openly, secretly I would like to have eighteen. Here at this point, for future clarity, let's take a quick look at me.

For many years I made a fascinating hobby of disliking music. I was active in the Society for the Prevention of Classical Music, and nobody could leap to the radio more swiftly than I to shut off any tremulous fragment of Puccini or Verdi which tried to invade the home. I could be alerted, cross the room and dial out a tenor before he could work his way from vesti to la giubba. I was so lightning fast at turning off operatic music that it was only because of a badly sprained ankle in 1946 that I discovered *Celeste* was followed closely by *Aida.* I worked at it. I had a reputation to maintain.

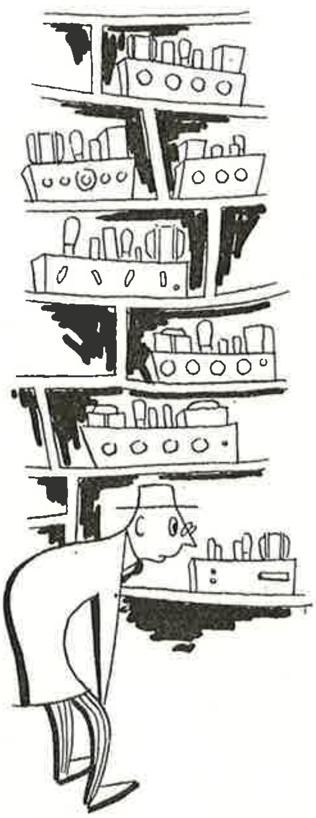
My surprising conversion came about in rather indirect fashion, a matter of being ambushed, then conked by Chabrier. One of my children had been taking ballet lessons a couple of years and one night during the ballet season I attended my first performance, merely to prove to myself what I felt sure of already, that I was tossing the money away. As for the ballet itself, well, that seemed a remarkable dodge for making a living, but it was the music which slipped up behind and disarmed me. I liked it, but that didn't disturb me too much. Actually, I've been perfectly willing all along to like music, providing it wasn't classical music. For years I had been a devoted listener to the works of Roy Acuff, but nothing else. So far as I know, mine was the only phonograph ever purchased and maintained for the sole purpose of enjoying Mr. Acuff and the Smoky Mountain Boys.

At the ballet I discovered that I liked unfamiliar music, and a little research in a long playing record catalogue revealed that what I had begun to like was classified as long-hair. I was rather shocked at this, but decided to venture in cautiously, fool around with *The Swan Lake, Invitation to the Dance,* Bizet's *Symphony in C* and, after a decent interval, *Petrouchka.* I took it easy at first, glancing back occasionally at Acuff, figuring I could throw it off at any time, like a kid beginning cigarettes. It was at that point when I met the hi-fi man lurking in the record store.

After I decided to buy a music system, there remained the questions of what to buy, how much to pay, and when to pay it. Being depressingly Scottish in both lineage and outlook, I wanted to spend less than four hundred dollars, considerably less, but at the same time I was impatient to get the music in the house.

There are two ways to select a system, neither of them totally satisfactory, since five components are the minimum required for a radio-phonograph and they may be made by five different manufacturers. Most makers of amplifiers do not make loudspeakers, and the makers of automatic record changers seem satisfied in their specialized field. The "insides" of a commercial and a custom phonograph are the same: turntable, cartridge, stylus, pick-up arm, amplifier and speaker. It is quality alone which allows one to be sold for less than twenty dollars while the other may cost as much as two thousand dollars.

In buying a system, a person may accept whatever components a salesman suggests, or he can visit the stores, listen to many combinations of amplifiers and speakers and then make up his own mind. Before parting with my money, I decided I would listen for at least a month. In New York and other large cities, a prospective customer can hear practically all the equipment available to the public, and I made the most of this.



Within four weeks I made twenty visits to five stores and listened for at least an hour at each visit. At the end of the first week I discovered happily that my ears were getting educated. Salesmen had begun suspecting that I was going to be a hard man to please. A few of them, not too many, began trying to close in too fast. At one sound studio, where I had repeatedly listened to two twelve-inch loudspeakers in the same price range, I decided one day that one was superior. Two days later I rechecked the speakers, played through the same amplifier and felt beyond question that I had been wrong, and that the second speaker was the one most pleasing to me. On that occasion a clerk (I cannot call him a salesman) seemed to feel that he was losing ground toward the ultimate sale and grew churlish, demanding to know why I didn't let well enough alone and stop changing my mind. I eventually bought the second speaker, but not from him. At the end of three weeks I began to feel that I knew my way around. I had decided to upgrade the ante to an even four hundred dollars, having discovered that, to my ears, an amplifier costing a hundred dollars sounded more than twice as good as one costing fifty. To my own satisfaction I had settled the classic question among hi-fi fans, that the amplifier is the most important unit of a system and that the monetary splurge should be made there.

Among people going into high fidelity there is nothing to buy more baffling than the baffle. A loudspeaker, to the uninitiated, looks like nothing so much as a hunk of junk and to make it acceptable socially and musically it requires a cabinet or baffle. At an early moment in my research I discovered corner cabinets. As the term implies, these sit in corners, thus minimizing sound-bounce from opposite walls. Some also are made according to what is called a folded-horn pattern. In these, the walls themselves form part of the "horn", helping to expand the bass tones of the speaker. One can spend more than seven hundred dollars for one of these. Fortunately, however, one needn't. I found one to fit my finances, but what I almost didn't find was a corner to put it in. For the first time I noticed that the apartment we have occupied for years has but one legitimate corner, and that is in the children's bedroom. Of the sixteen other corners in the apartment, all are broken up by doors, windows, radiators, offsets and obtuse angles, the cunning devices employed in modern architecture to crowd more usable space into limited dimensions.

When I mentioned this to a salesman he told me that it wasn't unusual for a man to buy a corner cabinet for his loudspeaker, only to call back desperately that he had no corner. Fortunately, I found a small right-angled corner in the living room and by closing doors on either side there is enough wall space to reflect and amplify the bass tones which exhaust through the vented back of the cabinet.

At the end of my four weeks and twenty visits I had put together, mentally, three different music systems. I had discovered that it is the accepted thing among hi-fi experts to work out at least three categories of equipment, in three distinct price brackets, and I was determined to be no exception. I was now moving in the hi-fi set.

For about a hundred dollars I could buy equipment which sounded good, but thirty days' experience had shown me that it would not satisfy me very long. For an outlay of seven hundred and fifty dollars I felt that a person (with more money than I) could buy the components for a system which could hardly be improved upon at any point. There are grounds for argument here, and I have heard them all, but I do not budge more than an extra fifty dollars to assemble the ultimate in home music reproduction, exclusive of cabinetry to house the amplifier and record changing equipment.

For the high fidelity system which considerably strained my economy, but has repaid handsomely in musical pleasure and education, I paid slightly less than four hundred dollars. Interpreted in dollars, and beginning with the system where the appreciation begins, the music comes from a sixty-five dollar loudspeaker enclosed in a fifty-eight dollar corner cabinet. For slightly less than seventy-five dollars I got an automatic record player with diamond stylus for long playing records, and a sapphire stylus for the few 78-rpm records I will play. The amplifier cost a hundred dollars, and the tone control panel required to operate this amplifier cost another hundred.

That comes to a nice round four hundred dollars, but it is necessary here to confess that I opened the wallet, somewhat reluctantly, one more time before I was satisfied.

After I had used this system two months I began to notice that the first full rapture of reality was missing from the music. The set hadn't changed, but I had. The music was still good, but I had a vague, disturbing feeling that it should be better. I added a tweeter and a dividing network to the speaker. A tweeter is a small speaker which brings out the high notes, leaving all other sounds to the large speaker. The network is a small unit, also mounted inside the cabinet, which divides the high treble from the electronic stream being sent in by the amplifier and sends the "highs" to the tweeter.

This additional equipment cost fifty dollars, but it brought new, clean sparkle to the music. With this present system — and believe me, I want nothing better — I can make the folks upstairs think that Toscanini and his crew have moved in below, or I can play symphonies at midnight with pleasure and satisfaction and the music will not be heard in an adjoining bedroom.

All in all this assembled phonograph cost me exactly a hundred dollars more than the three-fifty top I at first placed on the system, but quality in high fidelity, as in a suit of clothes or a box of fine cigars, is in the extra few dollars you finally manage to spend.

Among the considerable joys of bringing a superb music system into the home are also psychological reactions to sound vibrations which probably are as old as the human race. The feminine ear, as has long been known, does not respond with favour to shrill sounds. The day I announced with quiet authority that I intended to add a tweeter to the system to bring up the "highs", this was greeted with all the enthusiasm I could have expected if I had revealed plans to adopt a twenty-four-year-old hat check girl. The whole idea would have been quashed right there if it had not been for inspiration.

"But the two-way speaker system will have a switch for actually cutting *down* the highs, can slice them out altogether if we want to," I explained. This seemed to carry a certain appeal and the single speaker was built up to a two-way system of speakers in the same corner cabinet. Before that there had been occasional complaints that some of the music was too shrill, but since the modification was made there have been no complaints. I cannot explain why, except that now the high tones are true and undistorted, and possibly that the feminine ear demands not fewer highs, but better ones.

Along with the means to reproduce the treasuries of classical music there has come a sudden flowering of my musical tastes, a source of interest to long-haired friends, particularly the two well-known music critics on the newspaper where I work. In years past they had occasionally offered me tickets to operas and concerts, but as a moving spirit of the Society For the Suppression of Symphonic Music I had repaid their kind overtures with sneers and opprobium.

In fact, on my latest and forty-sixth birthday I could have said with considerable pride that I had never heard an opera, seen a ballet, nor attended a symphonic concert; and where composers were concerned I had somehow remained utterly unaware that there was any discernible difference between the works of Mozart and those of Stravinsky. But since that memorable evening when my dislike of classical music was disrobed by the ballet, and my subsequent purchase of hi-fi equipment, I have heard thirty-eight complete operas, and some of them several times. Most of these have been long playing record albums, but at least a dozen operas were both seen and heard at the Metropolitan Opera House, a place I had not previously troubled myself to visit in thirteen years in New York. On my own records, or those played over FM radio stations, I have heard symphonies, concertos and chamber works by the hundreds. I have been in my seat, hands respectfully joined, at three concerts conducted by Toscanini and many concerts by many others.

I have listened to a perfect profusion of great music, available day and night at the click of a switch, and enjoyed that regal prerogative of liking and disliking, enthroning favourites one week only to dethrone them the next and place new composers and compositions under the patronage of my royal preference. Several of the hi-fi stores are still on my calling list. There I listen to the new equipment and, occasionally, run into the gentleman who has seventeen loudspeakers.

I still take part in the round-robin discussions of "concert hall presence", a quality of sound which is the goal of too many of my new brethren in the fraternity of high fidelity.

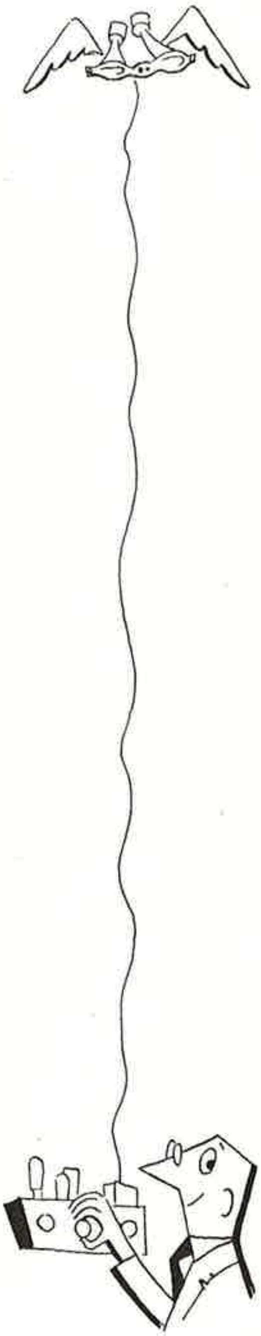
They strive and they buy every new piece of equipment, hoping somehow to make music from phonograph records sound in the concert hall. While most of these fellows know infinitely more than I do about the mechanics of high fidelity, I have discovered something that many of them will never realize.

Concert hall presence is not a matter of seventeen speakers, nor a fortune in amplifiers and intricate tone controls, but a simple matter of two dollars and seventy-five cents.

When I want music that sounds *exactly* like Dimitri Mitropoulos and the Philharmonic-Symphony Orchestra playing in Carnegie Hall, I know the only way on earth to have it. I go to Carnegie Hall.

Several times I have been asked the pointed question why it wouldn't be simpler to buy a fine phonograph, all in one piece in an attractive cabinet. That is a sensible question if I ever heard one, and there is one simple answer. There have been only a couple of ready-made fine phonographs able to reproduce recorded music with tonal quality comparable to that of a good high fidelity "rig", so-called, and these were not for the economic likes of me. Lesser commercial brands simply can't compete. For two decades we have been listening to AM radio, which is drastically limited in its range of musical tones, and we have been hearing it most of the time through equipment that is equally limited. We have grown accustomed not to the true, clear characteristics of individual instruments in an orchestra, but to a restricted amalgam of sound. Very thrilling sound now is being engineered into long playing phonograph records. None but reproducing equipment equally well engineered can bring out the life-like quality of the music in the microgrooves. Only the new magnetic tone cartridges, superb amplifiers and good loudspeakers in proper baffles will do this.

Being now in the inner circle of audio cognoscenti, I am surprised at how many people are still outside it, but also at how many are inside with me, in view of the amount of initiative it takes to get in. Except in a couple of high (or at least upper-middle) brow magazines, I had never seen any high fidelity equipment advertised until last year, when a few tiny blurbs managed to get into Carnegie Hall programs. Despite this, I find, the phenomenon is growing like crab grass. I suddenly see announcements of books on the subject; I receive invitations to join hi-fi clubs; I note that one record company is marking its disk-jackets: "Frequency range of this recording 25 to 20,000 cycles per second." It isn't certain that many people can hear tones quite that high or so low but, as they say in the hi-fi clubs, "It escapes me, but my dog enjoys it."



Actually, this is not as silly as it may sound, since the ability of equipment to reproduce such extremes is based on much the same principle of engineering as the excessive and almost never used power and speed of modern motor cars. A car built to make 115 miles an hour is a much more satisfactory vehicle at a sensible 60 miles an hour than would be a car which had a top limit of 60.

Everyone selling high fidelity equipment seems to be enjoying a bonanza, the sound studios of retail stores are busy places and I have done missionary work which brought a half dozen friends into the fold. There is one prospect, at this moment, unsuspecting, whom I am making elaborate plans to bring in.

I now read all the music and record reviews, and a few days ago I came upon this following effusion in the columns of the newspaper where I work. It was written by a music critic who has spent eighteen years on the job, known every artist of importance in that time, has been program annotator for the New York Philharmonic-Symphony Society, and has written books on music which are looked upon as standard works on operatic and symphonic subjects.

Here are two paragraphs from his column, not record reviews, for he does not review records, but his reaction to a recording:

"Listening to Columbia's long playing record of Claudio Muzio last Saturday, I had the weird feeling that the report of her death in 1936 was a case of mistaken identity. The illusion of life was complete. The voice — one of the most beautiful of all time — was warm with living reality. Almost every Muzio recording gives me that feeling. There isn't a note that doesn't throb with the haunting mystery of life.

"I heard her do 'Ah, non creddea', from Bellini's *Sonnambula* on Saturday, and it was a dream fashioned of wistful melody and longing. I heard her Mimi — aglow with first love and awakened youth and, almost like a page from life, came the third act of *La Traviata.* I shiver every time I hear it, and that to me is as good a test of great art as any."

This, without question, was the most intensely-felt and flattering review I ever heard conferred on a phonograph record, and since the original masters were made before 1936 — long before the engineering skills which go into recordings to-day — I assumed that the critic must have a high fidelity system, the like of which few human ears have ever heard and which must have cost far into the second thousand dollars.

I read the review twice, then walked across the editorial room to the critic friend's desk.

"What did you play the Muzio record on?" I asked, helping myself to the cache of chocolate candy he always keeps in a side drawer. He didn't answer immediately and I glanced at his face.

"What do you think I played it on?" he asked. "I played it on a phonograph." I remembered my own reaction to the same question three months ago. My friend couldn't tell me the name of his phonograph, wasn't even sure it had a name, but he paid $16.75 for it. He was sure of that.

I bought the Muzio record, played it on my system and enjoyed it, then pasted the review on the cardboard sleeve of the record. From the review I had been reminded of something rather important to the enjoyment of phonograph records, similar to the mighty striving for "concert hall presence", that we should listen *to* music; not *at* it. My critic friend had listened to Muzio with not only his ears, but with his memories and imagination, and had been rewarded with great pleasure. Not too many of us have that background, but there is certainly no reason for the other extreme, the practice of some of my hi-fi friends, to buy fine equipment and the best of modern recordings — then sit back with trembling ears and *defy* the combination to please them.

Somewhere between my pal with the seventeen speakers and the friend with the $16.75 phonograph there is a happy medium and I'm reasonably certain I know what it is. *I'm* now urging the *critic* to buy it.

However, my sales campaign is going to differ from that of the average crusading audiomaniac. I have a suspicion that my friend doesn't care a toot about sound reproduction, as such, so I'm going to preach music instead. And I mean to go slow. I recall my own first stunned reaction to a real jolt of high fidelity. It was too much of a good thing. I should have been more gently introduced.

In fact, I had a slight argument recently with one of the city's biggest sellers of audio equipment over a term which I thought he was using too loosely. Several times he referred to what the "average man" knows about high fidelity, and I told him that the "average man" in our country of 157 million people knows as little about the existence of fine music reproducing systems for the home as he knows about the Kremlin archives, or the mating habits of the auk. The "average man" has not yet heard about it! We who read every word written on the subject, who scan every new brochure and spec sheet and await with impatience the release of each new control panel, forget too soon that we are but the slightest fraction of a public which has yet to discover that this exciting new pleasure exists.

I am not a recluse in any sense of the word, and I feel that my neighbours and friends are of average awareness and intelligence, yet in the three months I have had hi-fi apparatus, only one person, among probably a hundred, has walked into the living room and recognized the amplifier, tuner and speaker as anything but a queer and oddly deployed phonograph. And the turntable had to be turning before most could deduce that. I'm happy to say that nearly all of them were impressed by the sound, and that several of them have bought systems of their own, but only one of them knew what it was, and that is because he works in a brokerage office where there is an LT (long talking) hi-fi fan. By which I imply simply that we, we happy few, have still a selling job to do.

New RCA Releases

RADIOTRON CRYSTAL-DIODES

The 1N34-A, 1N55-A, 1N56-A and 1N58-A are essentially low power rectifiers. They are very small in size, have great resistance to shock and vibration, and because of their hermetically sealed construction are not affected by moisture.

In addition, they have low shunt capacitance and are extremely efficient in applications where relatively small ac signals (fraction of a volt to several volts) must be rectified.

The 1N34-A is a general-purpose type intended for low-power rectification in applications such as isolating, clipping, and switching circuits, as well as in certain meter circuits.

The 1N55-A and 1N58-A are large-signal types having high peak inverse voltage ratings. They are especially useful in electronic computers, clamping circuits, dc restorer circuits, and in high-voltage probes.

The 1N56-A is a high-conduction type featuring exceptionally low dynamic impedance. It is especially useful for limiter service in frequency-modulation receivers.

The **Radiotron 1N38-A** and **1N54-A** are germanium crystal diodes of the point-contact type utilizing sealed-in-glass construction.

The 1N38-A is a large-signal type having a peak inverse voltage rating of 100 volts. It is especially useful in electronic computers and clamping circuits.

The 1N54-A is a high-back-resistance type especially intended for use in clipping circuits, high-impedance high-voltage probes, dc restorer circuits, and high-impedance detector circuits. The unusually high back resistance of this type permits the use of load resistance values as high as 100,000 ohms. Such values provide high diode rectification efficiency and good detector linearity.

LIMITING CLASS A OPERATION

A USEFUL DEVICE FOR GOOD QUALITY PUSH-PULL POWER AMPLIFIERS

By F. LANGFORD-SMITH, B.Sc., B.E.

Normal Class A operation of either triodes or tetrodes in push-pull limits the available power output, although it has other valuable features. One of these is that normal amounts of leakage inductance in the output transformer do not usually cause parasitic oscillations or transients. Of course, as is well known, all push-pull amplifiers have a tendency towards parasitic oscillation at ultra-high frequencies due to the capacitive coupling between the grid of one valve and the plate of its partner. However, with short leads, careful layout and, in the case of high slope valves possibly also with grip stoppers, parasitic oscillations in Class A amplifiers can easily be avoided.

Class AB_1 operation permits a higher output to be handled by the same pair of valves, but has two shortcomings which may be serious in good fidelity amplifiers. The first of these is that, due to the complete plate current cut-off which happens in each of the valves for part of the cycle, parasitic oscillations tend to occur over portions of the cycle in the vicinity of the points of plate current commencement and cut-off for each valve (Ref. 1). The resulting distortion — unless very marked — cannot be detected by ordinary distortion measurements, as it is partly masked by other non-linear distortion.

One method of checking the occurrence of these parasitic-transients is by means of a cathode ray oscilloscope connected across one side of the primary of the output transformer. These parasitic transients may be reduced by either of two methods, or a combination of both. The first is the use of a series RC network across each half of the primary of the output transformer, or from plate to plate. This method results in some loss of power output and, even so, may not be sufficient to eliminate the transient. The second method is to reduce the leakage inductance of the transformer by improved design, but transformers with very low values of leakage inductance are expensive.

The other shortcoming of Class AB_1 operation is the existence of a sharp kink in the linearity characteristic (input voltage plotted against output voltage) of the amplifier. This kink produces high order harmonic and intermodulation distortion, but the distressing effects on the listener are very much more pronounced than is indicated by conventional distortion measurements. Consequently a very large amount of negative feedback is required to reduce this form of distortion to an imperceptible level.

Both these shortcomings of Class AB_1 amplifiers are avoided by the use of limiting Class A operation.

Limiting Class A operation

Limiting Class A operation of a pair of power amplifier valves in push-pull is such that one valve just reaches plate current cut-off when the other reaches zero bias. Thus neither of the shortcomings of Class AB_1 amplifiers, as described above, applies to limiting Class A operation. It is desirable, on account of tolerances in valve characteristics, to arrange the operating conditions so that an average valve does not actually reach cut-off and has a comfortable margin to cover valve variations. Alternatively, output valves may be stabilized, matched (Ref. 2) and checked for plate current cut-off.

Limiting Class A operation is an intermediate condition between pure Class A (electrode voltages as for single valve operation) and Class AB_1. With a pair of push-pull valves, either triodes or pentodes, operating with constant plate and screen voltages, as the grid bias is increased the maximum power output increases, as also does the distortion. Limiting Class A operation is the condition giving the highest maximum power output without a serious increase in the non-linear distortion.

Published data for push-pull Class A operation often give a limiting Class A condition, or a very close approach to it.

Design procedure

The design procedure for limiting Class A operation of both triodes and pentodes is given below:—

1. Select suitable plate (and screen) voltages. These should not exceed the maximum ratings.

2. Decide on a value of load resistance, plate-to-plate. In most cases it will be possible to adopt a value published for push-pull Class A operation at the selected plate (and screen) voltages, and the use of such a value is quite safe. If a certain value of load resistance is known to be safe, then any higher value may safely be used with triodes.

If no published value of load resistance is available as a guide, the method of Fig. 13-36 on page 578 of the Radiotron Designer's Handbook (4th edition) may be used for triodes as a close approach to the load resistance to give maximum power output, but it will be necessary to check for plate dissipation. The plate dissipation is the difference between the plate power input and the power output. The plate power input is the product of the plate-to-cathode voltage and the average plate current at maximum power output. The average plate current at maximum power output may be derived either by measurement or graphically, using the method in the Radiotron Designer's Handbook on pages 579 to 580 for triodes. The procedure for pentodes is given on pages 583 to 584.

3. For any selected value of load resistance, it is possible to determine a value of grid bias to give limiting Class A operation. This will not necessarily be the condition giving maximum power output, unless the value of load resistance has been determined accordingly.

4. The next step is to determine the peak plate voltage swing, and either of two methods may be used. If the maximum power output is known, the peak plate voltage swing (E_{bs}) is given approximately by

$$E_{bs} = \sqrt{P_0 R_L / 2}$$

where P_0 = maximum power output
and R_L = load resistance plate-to-plate.

The other method makes use of the plate characteristic curves. Through the point ($E_b = E_{bb}$, $I_b = 0$) draw a loadline with a slope corresponding to a resistance of $R_L/4$ and extend this to cut the $E_c = 0$ curve. This is illustrated for a triode in Fig. 13-36 on page 578 of the Radiotron Designer's Handbook, where the point of intersection is marked A. Point A is the point of maximum plate current (I_{bm}) and minimum plate voltage (E_{min}). The peak plate voltage swing (E_{bs}) is given by $E_{bs} = E_{bb} - E_{min}$.

5. Having determined the peak plate voltage swing (E_{bs}), the maximum peak plate voltage (E_{bm}) is given very simply by

$$E_{bm} = E_{bb} + E_{bs}.$$

6. Refer to the plate characteristic curves and find the value of grid bias (E_{cm}) to give a plate current approaching cut-off at the maximum value of peak plate voltage, as determined in (5) above. Then take half of this value of grid bias, as the working bias for limiting Class A operation, at maximum power output.

This completes the normal design procedure.

Approximate method for triodes

The negative grid bias at which plate current cut-off occurs is given approximately by

$$E_{cm} \approx E_{bm}/\mu_{c0}$$

where E_{cm} = numerical value of negative grid bias at which plate current cut-off occurs,
E_{bm} = maximum peak plate voltage, as determined by step (5) above,
and μ_{c0} = amplification factor to give plate current cut-off at high plate voltages. Some approximate values of μ_{c0} are given below.

Valve Type	μ_{c0}
2A3	3.7
6L6-G	6.7
6V6-GT	7.1
807	6.7
KT66	6.5

Approximate method for pentodes

The negative grid bias at which plate current cut-off occurs is given approximately by

$$E_{cm} \approx E_{c2}/\mu_{c0}$$

where E_{c2} = screen voltage
and μ_{c0} is the same as for triodes.

To determine whether a particular published operating condition is limiting Class A

Example: KT66 Push-pull amplifier "Class AB_1" triode connection (see AWV Radiotron Valve Data Book RV2, pages 241 and 245). Published conditions — plate voltage 400 volts, peak a-f voltage (grid-to-grid) 80 volts, load resistance plate-to-plate (R_L) 4000 ohms, maximum signal power output (P_0) 14.5 watts.

There are two methods of determining the peak plate voltage swing, either from the power output or by drawing a loadline.

1. Peak plate voltage swing (E_{bs})

$$= \sqrt{P_0 R_L / 2}$$
$$= \sqrt{14.5 \times 4000 / 2}$$
$$= 170 \text{ volts.}$$

2. On the plate characteristic curves (page 245) draw a half composite loadline through the point E_b = 400 volts, I_b = 0, with a slope corresponding to a resistance of $R_L/4$ = 400/4 = 1000 ohms. Extrapolate the E_G = 0 curve upwards to meet the loadline — they will meet at a point approximately E_b = 220 volts, I_b = 180 mA. The peak plate voltage swing (E_{bs}) is therefore 400 — 220 = 180 volts, which differs slightly from the value calculated above from the power output. The smaller of the two voltages is then adopted as the basis of further calculations.

Then determine the maximum peak plate voltage, given by 400 + 170 = 570 volts.

Referring to the plate characteristic curves, with a plate voltage of 570 volts, and a grid voltage equal to the grid-to-grid value (80 volts) it will be seen that the plate current is about 5 mA. Thus cut-off does not occur under the worst possible conditions, and the operation is limiting Class A.

It is obvious from the plate characteristic curves that any appreciable increase in load resistance would result in plate current cut-off and Class AB_1 operation at maximum power output.

* * *

Ref. 1, Sah, A. P-T. "Quasi-transients in Class B audio-frequency push-pull amplifiers" Proc. I.R.E., 24.11 (Nov., 1936), 1522.

Ref. 2, "Radiotron Designer's Handbook", 4th ed., page 580.

By K. Fowler and H. Lippert.

TV POWER SUPPLIES

1. Introduction.

Two separate power supplies are usually required in a TV receiver. The low voltage supply, which is very similar to that used in a large radio receiver, provides (1) the d-c voltages up to approximately 400 volts for the plate and screen elements of the operating tubes, and (2) the low voltage a-c, usually at 6.3 volts, for heating the filaments of the tubes. Occasionally, the heater supply on certain critical tubes is obtained from a d-c source. Modifications of the above may be necessitated by the use of "transformerless" power supplies which will be discussed later. A separate power supply is used to provide the high voltage for the anode of the picture tube. This may require 2 to 14 kilovolts for direct view picture tubes and up to approximately 30 kilovolts for projection tubes.

2. Rectifiers — General.

There are two types of rectifiers in general use for television low voltage power supplies; they are (1) the high vacuum tube rectifier, and (2) the selenium rectifier. The selenium rectifier has only recently been used for this application but its future usage will undoubtedly increase.

(a) Vacuum tube rectifier.

There are two general types of tube rectifiers. The one used in television and most radio power supplies is the "hard" or diode vacuum tube rectifier. This type is used to supply a small or medium value of current. Where high current is required, a gas-filled rectifier tube is sometimes used in large radio receivers and amplifiers. Because of the r-f interference set up by the gas discharge, the gas-filled rectifier is not used in TV receivers as this interference will adversely affect the reception.

Two of the typical rectifiers used in TV low voltage power supplies are listed below. The characteristics shown are applicable when using a capacity input filter.

Rating.	5Y3GT.	5U4G.
Filament voltage	5.0 v.	5.0 v.
Filament current	2.0 a.	3.0 a.
Peak inverse voltage	1400 v.	1550 v.
A-C plate supply per plate .	350 v.	450 v.
D-C output current	125 ma.	225 ma.
Tube voltage drop at rated output current	60 v.	58 v.

The greatest disadvantage with a high vacuum type of rectifier is the internal IxR drop in the tube. This drop is proportional to the amount of current flow in the tube. At rated output current it becomes approximately 60 volts. In the 5U4G rectifier tube this amounts to a considerable power loss. The "peak inverse voltage" value shown in the above chart represents the highest instantaneous voltage which may be safely applied between plate and filament of the tube elements when the polarity is opposite to that which causes current to flow in the tube. The peak inverse voltage depends upon the rectifier and filter circuits used and may be as high as 2.8 times the rms of the applied plate voltage.

Figure 12-1 shows a full wave rectifier circuit using two diodes. The secondary has a centre-tapped winding so that the load may be connected midway between the ends of the secondary winding, permitting equal plate current flow through each tube during the conduction period. A voltage as shown is impressed on the tube V_1 in series with the load resistor R_1. During the half-cycles marked t_1, the plate of V_1 is positive in respect to the cathode and electrons will flow through V_1 as shown by the arrows marked (1). This current causes a voltage drop across R_1 of a polarity as shown. During the same time interval tube V_2, in series with R_1, has a negative voltage impressed on its plate in respect to its cathode so that current will not flow. At a half cycle later, represented by t_2, the voltage at the two tube plates reverses, which makes V_2 conducting and V_1 non-conducting. The electron flow in this case is represented by the arrow (2) and is in the same direction through R_1 as when tube V_1 is conducting. Thus it will be seen that only one tube is conducting at any one half-cycle; however, a current is flowing through R_1 on both half cycles. This is called full-wave rectification.

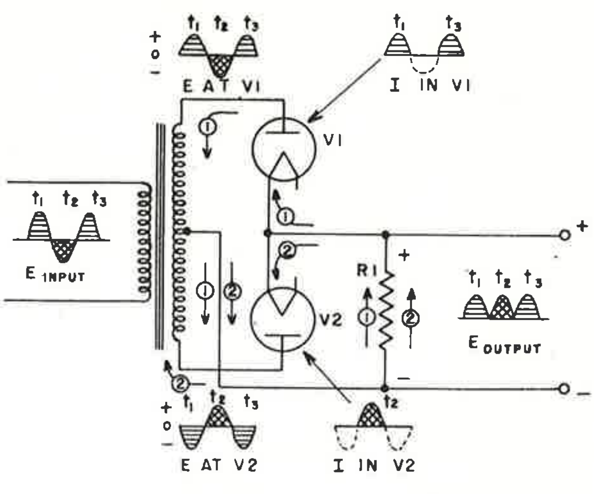


Fig. 12-1. Full wave rectification using transformer and diodes.

By courtesy of AGE, with acknowledgement to International General Electric Co. of U.S.A.

If tube V_2 was left out of the circuit, then the current through R_1 would flow for only every other half cycle. This is called a half-wave rectifier circuit. A full-wave rectifier is much more efficient than a half-wave rectifier as the output voltage fluctuation is much easier to smooth out or filter and the voltage output will be higher.

(b) Selenium rectifier.

Under certain conditions, combinations of thin films of dissimilar metals permit electrons to flow, at their junction, more readily in one direction than in the opposite direction. One efficient combination is the use of a thin film of selenium in conjunction with a metallic surface, such as iron. Selenium rectifiers utilize the rectifying action obtained when a properly processed selenium film is formed on a metallic surface.

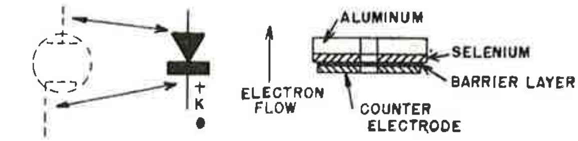


Fig. 12-2. Selenium rectifier.

The characteristics of a selenium rectifier are similar to those of a copper-oxide rectifier insofar as stability and long life are concerned. However, the resistance of the selenium rectifier in the forward direction is less, so that its efficiency and current carrying capacity are greater for a given physical size.

The selenium rectifier is represented schematically by a symbol as shown in figure 12-2. Its equivalent in physical construction and vacuum tube symbol are also shown in this illustration. One of the terminals of the rectifier is marked with a "+" or "K" or "red paint" dot, depending upon the manufacturer. The terminal thus marked corresponds to the cathode of a rectifier tube, as indicated in figure 12-2.

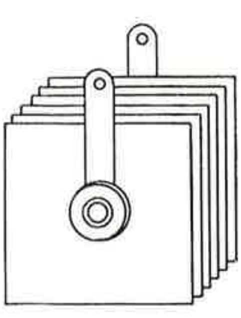


Fig. 12-3. Physical appearance of selenium rectifier.

A typical unit such as used in a G.E. television receiver is shown in figure 12-3. This consists of six selenium rectifier elements, stacked and fastened together at their centres. Stacking of these elements is necessary in most applications since a single element has only an allowable back voltage of a little over 20 volts rms. Thus, a series stack of at least five separate rectifier elements must be used when operated at a line voltage of 117 volts. As shown in figure 12-2, each plate consists essentially of an aluminium support plate to which is applied a very thin film of specially treated selenium. The aluminium plate acts as a heat radiator and support and also to make electrical contact with one side of the selenium layer. The selenium film is heat treated to obtain a crystalline structure, after which a low melting point alloy is sprayed on the selenium. This metallic layer sprayed on the selenium surface acts as one of the electrodes and is called the counter electrode. This counter electrode corresponds to the cathode of a rectifier tube, while the selenium surface corresponds to the plate or anode.

After the metallic layer (counter-electrode) is sprayed on the selenium surface, subsequent electro-chemical processes form a barrier layer or film between the selenium surface and the counter-electrode. This barrier layer which separates the two electrodes may be compared to the space between the anode and cathode in a rectifier tube, since it separates the anode and cathode, yet allows electrons to pass freely between these elements upon the application of a suitable potential.

The operation of this rectifier is as follows: The sprayed-metal counter electrode has an abundance of free electrons (similar to the cathode of a rectifier tube), while the selenium layer, which corresponds to the plate of a rectifier tube, has relatively few free electrons. If the two electrodes are connected to a source of potential so that the selenium electrode is positive with respect to the metallic counter electrode, a high current will flow through the barrier layer from the metallic counter electrode to the selenium electrode. This is because there are many free electrons on the counter electrode which are attracted toward the positive potential on the selenium electrode. These free electrons readily pass through the barrier layer on the way to the selenium electrode just as in the case of electrons passing through the space between cathode and plate of a rectifier tube. If the polarity of the source of potential is reversed, so that the selenium electrode is negative, the resulting current will be much smaller due to the relatively few free electrons on the selenium electrode. Because of this asymmetrical property it is possible to rectify alternating current.

Typical electrical characteristics of a selenium rectifier as used in the Model 805 receiver are as follows:

Max. RMS Input Voltage	130
Max. Inverse Peak Voltage	380
Max. Peak Current (M.A.)	2000
Max. D-C Output Current (M.A.)	250
Approx. Rectifier Voltage Drop	5
Max. Plate Operating Temperature	75°C

One of the principal advantages of a selenium rectifier is the relatively low internal voltage drop at rated output current. The 5 volt drop in the selenium rectifier compares to the 58 volt drop in a vacuum tube rectifier of the same current rating. This gives a selenium rectifier a distinct advantage over a vacuum tube when used in a transformerless power supply. One of the limitations of the selenium rectifier is the necessity of restricting its heating during operation, otherwise its life expectancy will deteriorate rapidly.

(c) Use of selenium rectifiers to supply B+ requirements.

Since selenium rectifiers must be used at relatively low a-c input voltages, voltage doubling must be resorted to in order to obtain the necessary d-c output voltage for television receiver operation. Figure 12-4 shows a conventional full-wave voltage doubling circuit using two selenium rectifier units, operating on a 117V a-c power line. Its operation is as follows: When the instantaneous line voltage is positive as represented by time, t_1, electrons will flow through rectifier X_1 as shown by the arrow (1). This electron flow through X_1 charges the capacitor

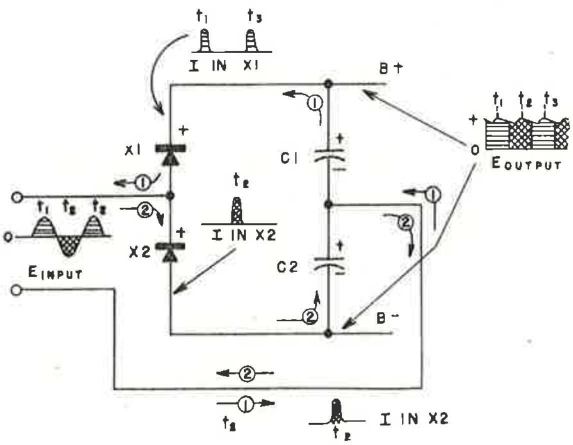


Fig. 12-4. Full wave voltage doubler.

C_1 to near peak value of the line voltage with the polarity as shown, with electrons flowing out of C_1, through X_1 and the external circuit into the lower plate of C_1. There is no appreciable electron flow through X_2 during this part of the cycle since the polarity of the applied voltage is incorrect for "forward" conduction through X_2. During the time t_2, electron flow through X_1 becomes nil while full forward conduction takes place through X_2 which charges capacitor C_2 to a near peak value. The path of electron flow during this period is shown by the arrows (2). At t_3 the current flow again is through X_1, which is the same as at time t_1. Assuming that C_1 does not discharge appreciably when C_2 is charging and vice versa, then at the end of a full cycle represented by $t_1 + t_2$ the charges on C_1 and C_2 will add to give approximately twice the peak voltage of the input rms voltage. It will be noted that the ripple voltage frequency at the output of the supply shown in figure 12-4 is twice that of the line frequency which is characteristic of full-wave rectification.

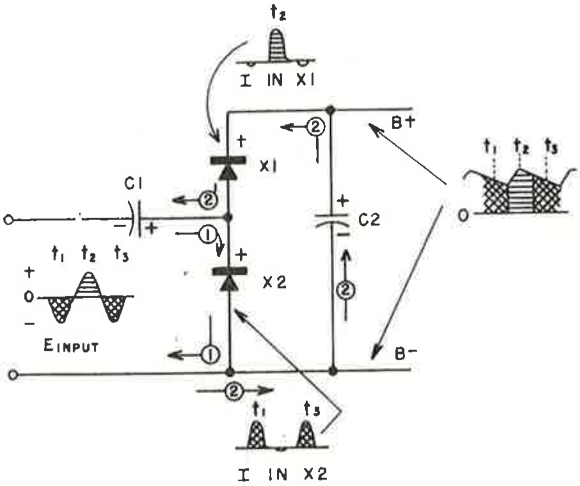


Fig. 12-5. Half wave voltage doubler.

Figure 12-5 shows a half-wave voltage doubling circuit. The advantage of this circuit over that shown in Figure 12-4 is that one side of the power line becomes the B — of the power supply, resulting in less voltage stress between cathode and heaters of certain tubes when the heaters are connected in series across the a-c line. Its operation is as follows: At time t_1 when the instantaneous line voltage is negative, electrons will flow through X_2 and charge capacitor C_1 with a near peak voltage at the polarity as shown. The path of electron flow for this half cycle is shown by the arrows (1). During the next half cycle, t_2, the instantaneous polarity of the line voltage is such that it will add to the charge on the capacitor and will cause electrons to flow through rectifier X_1 as shown by the arrows (2). Since C_1 discharges in series with the line voltage, through X_1, capacitor C_2 charges to a value equivalent to that of the near peak line value plus the charge on capacitor C_1 at a polarity as shown. This value will be nearly twice the peak line voltage. Since capacitor C_2 receives its charge at every other half cycle (60 cycle rate), it is referred to as a half-wave rectifier circuit. This has the disadvantage of requiring more filtering in its output.

3. Low voltage transformer power supply.

A typical low voltage power supply is shown in Figure 12-6. This unit supplies all operating voltages except that required by the picture tube anode. Two rectifier tubes are used to supply the three different d-c output voltage levels. A Type 5Y3GT (V_2) tube is used to supply the lower voltage levels required by most of the r-f, i-f, video and special purpose tubes. A Type 5U4G rectifier tube (V_1) supplies the higher voltage and current requirements for the audio output and horizontal sweep output tubes. It will be noted that a portion of the high voltage secondary winding of the transformer is common to both rectifier tubes, V_1 and

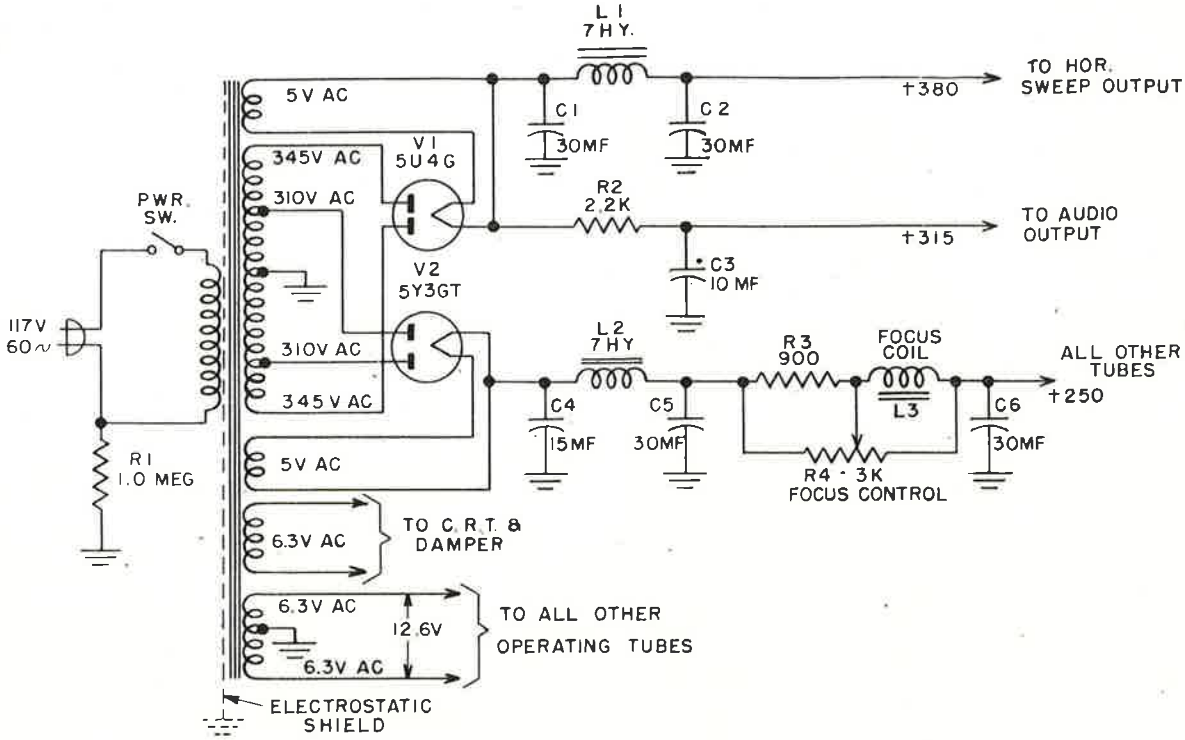


Fig. 12-6. Typical low voltage power supply.

V_2, with the Type 5Y3G tube, V_2, being supplied from lower voltage taps on the winding. Both tubes are connected as full wave rectifiers.

The 380 volt output is supplied through a single section L-C filter consisting of L_1, C_1 and C_2, which provides adequate filtering for the plate and screen elements of the horizontal sweep output tube. The audio output tube plate circuit which does not require extensive filtering is supplied through an R-C filter consisting of R_2, C_1 and C_3 at a voltage level of 315 volts. All other tubes are supplied at the 250 volt output through a two section filter which follows V_2. The first section of the filter is a conventional L-C filter consisting of C_4, C_5 and L_2, while the second section consists of R, L, and C. The inductance L_3 in this section is the electromagnet portion of the focus coil. The current which is permitted to flow through this coil and which is controlled by R_4 provides a variable means of adjusting the focus of the picture tube. A larger portion of this focusing field is supplied by a permanent magnet which is also a part of L_3. The resistance (combination of R_3 and R_4) in the circuit between C_5 and C_6 also contributes towards the filtering of this section.

An electrostatic shield, shown in dashed line in Figure 12-6, is incorporated between the primary and secondary windings of the transformer. This prevents interference that may be prevalent in the power line from being electrostatically coupled through the transformer windings into the power supply circuit of the receiver. The resistor, R_1, is connected between one side of the line and the chassis to provide a ground return path through the power line for the chassis in case no ground connection is made to the chassis at the time of installation. This is a precautionary measure to guard against possible puncture of the power transformer winding insulation by static electricity charges on an ungrounded chassis. Since the antenna system indirectly connects to the chassis through the r-f input system, static accumulations on the antenna might dissipate to ground via the power transformer to the power line circuit, if the chassis were ungrounded.

The power input requirements for the power supply described in the preceding paragraph will be approximately 225 watts.

4. Low voltage "transformerless" power supply.

The power supply shown in Figure 12-7 is a "transformerless" type using selenium rectifiers instead of vacuum tube rectifiers to supply the d-c voltages. This power supply has several advantages over the conventional supply as shown in Figure 12-6.

1. Elimination of power transformer reduces the weight and size of receiver chassis. With elimination of the magnetic field caused by a power transformer the chassis can be made more compact. When a power transformer is used, it must be located as far away from the picture tube as possible to prevent distortion of the picture by its magnetic field.
2. Lower cost to build and maintain.

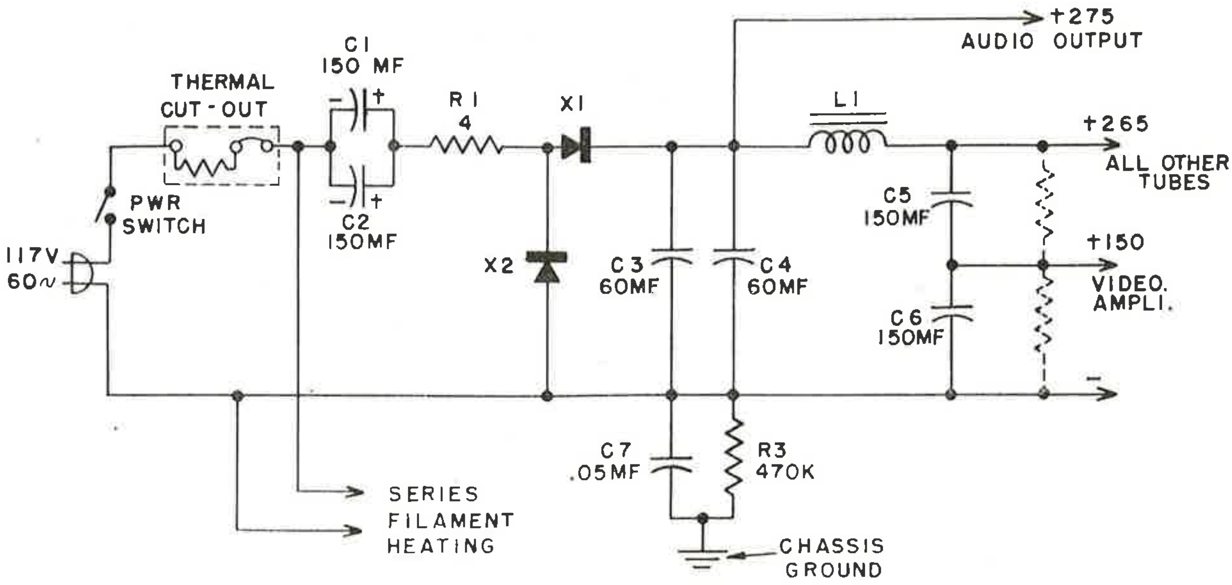


Fig. 12-7. Transformerless low voltage power supply.

3. The selenium rectifier saves the filament wattage required by rectifier tubes and it also has a lower internal drop. This results in a considerable saving in the power requirements of the receiver. With less power consumption the chassis will operate at a lower temperature, resulting in less stress on most components.

The circuit shown in Figure 12-7 is a half-wave voltage doubler. The operation of this circuit was described under "Rectifiers" and illustrated in Figure 12-5. Because of the half-wave rectification, relatively large filter capacitor values must be used in the filter. The audio output tube obtains its plate supply from a point prior to the filter choke L_1, while all other tubes are supplied at the output voltage of +265 volts. A tap midway between C_5 and C_6 supplies approximately 150 volts to the video amplifier. The resistors shown in dashed lines represent actual tube loads across these capacitors. X_1 and X_2 are selenium rectifiers with a rating of 250 milliamperes.

The 4 ohm resistor, R_1, is a peak current limiter. In case of a short circuit in the rectifier, it prevents the current from reaching extremely high values before the thermal cut-out has an opportunity to open. The thermal cut-out depends upon the line current drawn by the receiver to heat a resistance element sufficiently on overload, to cause the thermostat element to open the circuit.

With this type of power supply one side of the line is also common to B —. To provide protection from shock to the operator in case of accidental contact with the chassis, the B — for the receiver is maintained as a bus and the chassis is connected to B — by a resistor, R_3 and capacitor, C_7. The values are such that the current will be limited so that no serious bodily harm can result. This, of course, provides a more difficult manufacturing problem, as the B — or ground return for the electrical circuits must be insulated fom the chassis ground.

5. Filament power supply.

There are two methods of heating the filaments of the operating tubes. They are:

1. Use of 6.3 volt and 5.0 volt tubes to be supplied by low voltage windings on a power transformer.

2. Connection of tube filaments in series or series-parallel combination so that they can connect directly across the a-c line.

The shunt connection (1) is used when a power supply such as that in Figure 12-6 is incorporated, while the series lighting (2) is used with the power supply shown in Figure 12-7.

Figure 12-8 shows the circuit for heating the operating tubes on a G-E Model 810 receiver. This makes use of a 12.6 volt secondary winding which is centre-tapped and connected to ground. The tubes are connected so that the current required by each string of tubes is approximately equal. A 1500 mmf. ceramic capacitor shown across the upper string of tubes is used at the R-F tube filament to prevent r-f coupling with other tubes through the filament connecting leads.

The oscillator tube on receivers other than those incorporating intercarrier sound system are subject to hum modulation when their filament is heated from an a-c source. This is particularly true on the high frequency channels. To overcome this difficulty, the oscillator tube is heated by d-c as shown in Figure 12-8. SR_1 is a selenium rectifier which is connected across the 12.6 volt winding of the transformer in a full wave rectifier circuit. C_1

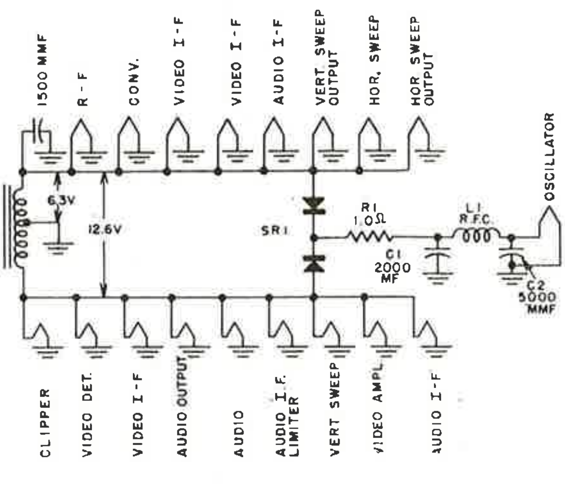


Fig. 12-8. Shunt transformer filament heating.

is a 2000 mfd. capacitor used for smoothing out the ripple. C_2 and L_1 are components of an r-f filter used to prevent interference from being carried through the filament wiring into the oscillator section and then into the convertor. R_1 is used to reduce the voltage to the proper value for the 6.3 volt oscillator tube section.

The "transformerless" power supply as used in the G-E Model 805 receiver makes use of a series parallel connection of tubes to heat the filaments directly from the 117 volt line. Series heating is dependent upon the use of tubes with the same current requirements. Since all tubes, except the picture tube, require 0.3 ampere for the filament they can readily be connected in series. However, because of the large quantity of tubes used, it is necessary to divide the tubes into two series strings and then connect these two strings in parallel. This arrangement works out very well as the picture tube requires 0.6 ampere. Thus the combined current of both parallel strings are taken through the picture tube.

The past objection to series heating of tube filaments across the line voltage source is the initial current surge through the tube filament when the power is first turned on. This is due to the fact that the normal tube filament has a positive resistance characteristic resulting in abnormally high current until the filament gets up to its operating temperature. This has resulted in premature failure of tubes in the a-c - d-c type of receivers. To correct for this condition, a special resistor (Globar) is used in series with each string of series connected tubes. These resistors are designated as R_1 and R_2 in Figure 12-9. These resistors have the opposite resistance characteristic (negative temperature coefficient) of that of the tube filaments during heating and compensate so thoroughly that the filament current never rises above the normal current rating of the tubes between the initial cold and the final hot filament operating temperatures. The resistance value of a Globar resistor changes from a cold value of approximately 900 ohms to a hot value of 75 ohms during the filament heating cycle.

Because of the initial high resistance value when cold, the heating of the filaments to their operating temperature takes a somewhat longer time than when the resistors are not used. This time is approximately 1½ minutes. The use of Globar resistors in a series heating arrangement as shown in Figure 12-9 is easier on the tubes than when the filaments are heated by a transformer in a conventional power supply. The tubes when supplied by a transformer show a high initial current which is only reduced somewhat over the series lighting (without Globar resistors) because of the poorer regulation of the transformer supply.

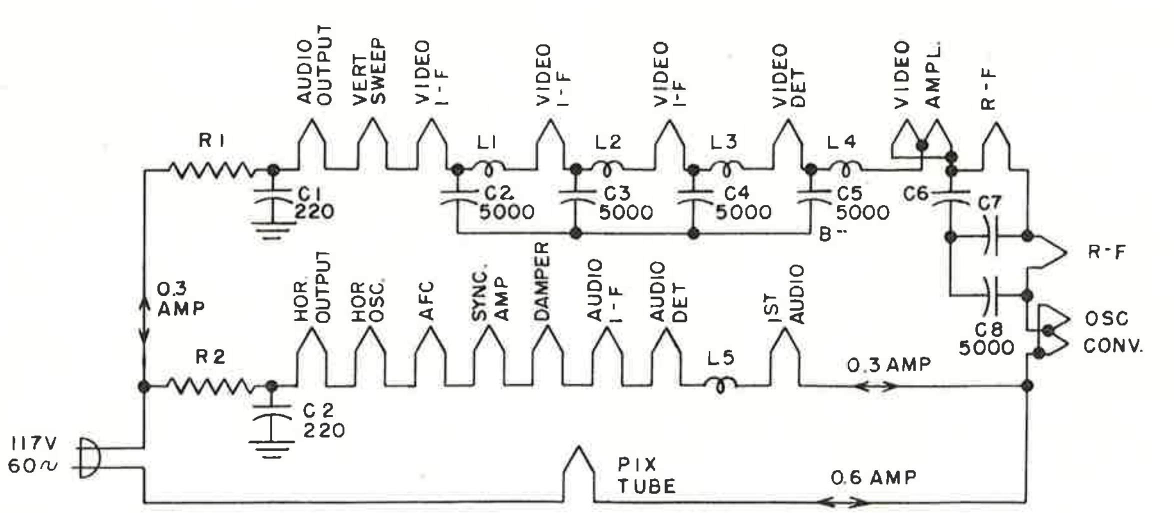


Fig. 12-9. Series filament heating.

6. High voltage power supply — General.

Because of the difference in characteristics and method of voltage generation, the high voltage power supply is constructed separately from the low voltage supply. Since the picture tube anode requires a high voltage at a low current, the supply requirements may be from 100 to 200 microamperes at a voltage of 8 to 30 kilovolts. Three types of supplies may be used for the purpose. They are:

(1) Conventional power transformer — 60 cycle supply.

(2) R-F oscillator supply.

(3) Horizontal sweep output "kick" supply.

7. 60-cycle transformer — H.V. supply.

The earliest circuit used for supplying the high voltage made use of a conventional power transformer operating from the 60 cycle power line for step-up of the voltage, after which it was rectified and filtered. Such a supply as used in a GE prewar TV receiver is shown in Figure 12-10. The transformer, T_1, steps up the voltage to a suitable level to obtain the desired d-c voltage after rectification. This voltage is then applied to a Type 879 rectifier tube, V_1, connected in a half-wave rectifier circuit. The resistor R_1 is used to limit the current in case of a rectifier tube short or accidental short of the filter capacitor to ground.

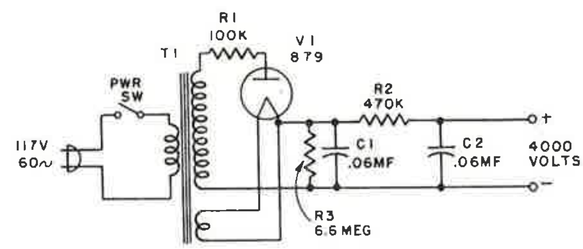


Fig. 12-10. High voltage supply — 60 cycles.

Because of the low current requirement, a resistor is used instead of a choke in the filter. The R-C filter consists of C_1, C_2 and R_2. By making the resistor value large (470K ohms), the capacitors in the filter may be made small. This is particularly important in a power supply of this voltage rating as: (1) the cost of high capacity capacitors insulated for high voltage becomes very high, and (2) the lower the value of the capacitor, the less will be the danger of receiving a fatal or harmful shock in case of accidental contact. R_3 is a bleeder resistor which dissipates the charge on the capacitors after the power has been turned off.

This type of power supply is no longer used in modern receivers and has been succeeded by the power supplies as shown in Figures 12-11 and 12-12. This obsolescence has been principally brought about by the high cost of this supply and the danger of harmful or fatal shock in case of accidental contact.

8. R-F oscillator HV supply.

A typical "r-f oscillator" power supply for obtaining a high voltage at low current is shown in Figure 12-11. This supply depends upon the operation of a tuned step-up transformer connected in the plate circuit of a self-excited oscillator circuit as the a-c high voltage source. The oscillator which makes use of a medium power pentode operates at a frequency of 50 kc to 300 kc. The high voltage at r-f developed across the secondary winding is rectified by a rectifier tube which obtains its filament heating from the output of the oscillator tube.

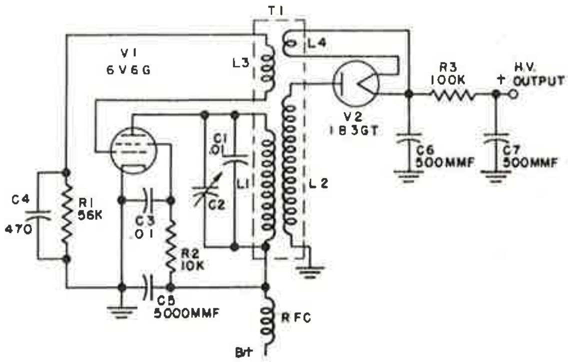


Fig. 12-11. R-F osc. high voltage power supply.

The use of a high frequency power source permits the design of the step-up transformer with low inductance, air core and simplified insulation due to fewer turns which, compared to a 60-cycle transformer, results in lower cost, lighter weight and fewer design problems. By rectifying a high radio frequency, the filter requirements are much less permitting the use of small capacitors in the filter. Thus with low storage capacity filters and the input power generated by a vacuum-tube oscillator, which automatically limits the possible power output, this construction provides a relatively safe source of high voltage. Any additional load other than that required by the picture tube such as accidental contact with the HV circuit, causes the voltage to drop rapidly.

The circuit shown in Figure 12-11 makes use of a Type 6V6G tube (V_1) connected in a conventional tickler feedback oscillator circuit. In the plate circuit of V_1 is a radio frequency transformer T_1 which consists of two tuned coupled circuits, L_1 and L_2, and a tickler winding, L_3. L_4 is a single-turn loop used for filament lighting. The primary winding, L_1, of the transformer is tuned by a fixed capacitor C_1 and a variable capacitor C_2, and is designed to tune near the resonant frequency of the secondary winding, L_2. The secondary frequency is established by the secondary inductance and the circuit capacitances consisting of distributed coil capacitance, rectifier capacitance, and stray capacitance. The secondary circuit has, therefore, a natural frequency which determines the operating frequency of the transformer.

The oscillator voltage developed across the primary tank circuit, L_1-C_1, is stepped up by the square root of the ratio of secondary to primary impedance. Thus, to provide high voltage step-up, it is necessary to design the secondary for a very high impedance which requires a construction of the secondary with low capacity and high inductance.

Oscillation takes place by feeding back a portion of the plate voltage into the grid circuit in proper phase relation. This is done by the addition of the tickler winding L_3. R_1 and C_4 are the grid leak and capacitor and are chosen to give Class C operation of the oscillator.

The rectifier tube, V_2, is a Type 1B3GT tube which is designed with a very low power requirement for filament heating. Since it requires only 1.25 volts at 0.25 ampere, a single turn winding around the plate tank circuit will have sufficient r-f voltage induced to fill this requirement. This is a big advantage over conventional high voltage rectifier filament sources, since it does not require an expensive 60 cycle transformer with high voltage insulation for filament lighting only. The R-C filter consisting of C_6, C_7 and R_3, smooths the r-f ripple to essentially a pure d-c. C_6 and C_7 are moulded capacitors of small physical dimension and having a rating of 500 $\mu\mu$f. at a working voltage of 15 kilovolts. The current output of such a supply may be rated at 200 microamperes.

9. Kick or flyback type of HV supply.

Whenever magnetic deflection of the picture tube is incorporated, the HV may be obtained readily by the addition of a few components in the horizontal deflection output circuit. For this reason, this supply is most universally used in TV receivers at present. Figure 12-12 shows the circuit used in the Model 835 TV receiver which delivers approximately 9KV to a Type 10FP4 picture tube.

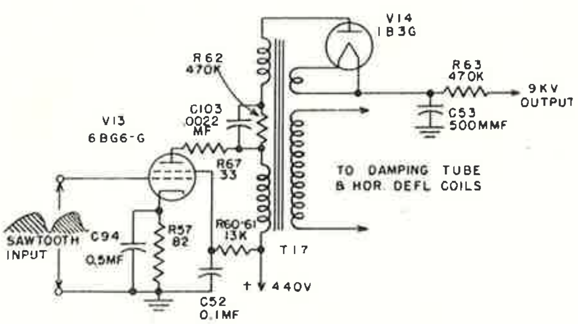


Fig. 12-12. Flyback high voltage power supply.

The name for this supply originates from the fact that the rectifier plate voltage is derived from the horizontal deflection circuit during the flyback or retrace portion of the sweep. In Chapter 9 was described the voltage waveshape associated with an inductive load such as the deflection coils represent, in order to obtain a linear sawtooth current waveform through the coils. This is shown in Figure 12-13, and represents the voltage and current in the plate circuit of the Type 6BG6G tube, V_{13}.

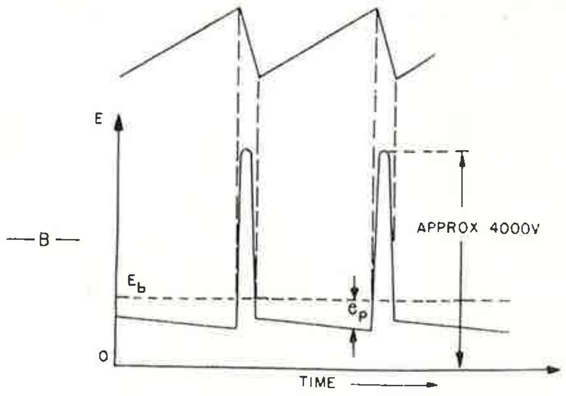


Fig. 12-13. Voltage and current waves in sweep output circuit.

The horizontal deflection coil and transformer appears as an inductive load with distributed capacity to the output tube, V_{13}. Thus when the current, during retrace, is caused to collapse it induces a high inductive "kick" voltage in this tuned circuit and would cause the circuit to oscillate violently if it weren't for the damper tube. The damper tube permits the first half cycle of the oscillation to take place, after which the oscillation is stopped. This half cycle oscillation performs the function of allowing the beam to rapidly move back to the left-hand edge after the trace cycle is completed and it also is used to generate the high voltage. The high voltage peak of 4000 volts shown in (B) of Figure 12-13 represents this half cycle oscillation as it appears in the primary winding of T_{17}. On the secondary, it is a negative-going voltage of approximately 1000 volts as described in the deflection circuit description in Chapter 9.

The 4000 volt pulse appearing in the plate winding of T_{17} is further increased by means of an additional winding connected in series with the regular plate winding is indicated in Figure 12-12. This additional winding, through auto-transformer action, steps up the voltage pulse to approximately 9,500 volts. This is applied to the plate of a half-wave, high voltage rectifier tube, Type 1B3GT. After rectification, the output voltage is filtered by means of an R-C filter consisting of C_{53} and R_{63}. Due to the comparatively high frequency of the pulses (15,750 cps), an R-C filter circuit can be used, with the value of the filter capacitor being only 500 $\mu\mu$f. With the use of such a low capacity value, the capacitor cannot store a dangerous charge with the consequent reduction of danger when service to the supply is necessary. Another safety feature of this supply is that when the output current from the high voltage rectifier exceeds approximately 200 microamperes, the voltage drops very rapidly to a low value due to the poor regulation of the circuit. However, the regulation is more than adequate to supply the needs of the picture tube.

As described previously, the Type 1B3GT tube requires only ¼-watt for filament lighting, thus the filament power may be derived from the sweep output transformer by means of a single turn loop around the core of the sweep transformer, T_{17}. This eliminates the need for a conventional 60-cycle filament transformer which would have to be insulated for at least 15 kilovolts.

The resistor, R_{62}, is connected in series with the two primary windings of the sweep transformer, T_{17}, to limit the current from the B+ which supplies the plate of V_{13}. This will not only prevent a painful burn in case the high voltage section is accidentally contacted, but will also prevent excessive current flow through the transformer winding in case of an accidental short in the high voltage section of the primary winding. C_{103} is used in shunt with R_{62} to by-pass the pulse voltage around R_{62}.

10. 30 KV Hi-voltage supply for projection TV.

To provide the brilliance necessary to project a picture to a screen, size 18" x 24", a special purpose kinescope operating with approximately 27 kilovolts on the second anode is required. In the GE Model 901 projection receiver, a Type 5TP4 projection tube is used with 28 kilovolts on the second anode and 4300 to 5500 volts used on the 1st anode for focussing purposes.

The only practical method of obtaining 30 kv with a single rectifier tube would be by means of a 60-cycle transformer supply. This would have a prohibitive cost since all components would have to be designed for a voltage rating exceeding this value. The filter capacitors would have to have a fairly large capacity rating for this low frequency which would make them bulky and expensive. The fact that their capacity value would have to be high, makes them a fatal shock hazard in case of accidental contact. Thus for the above reasons a voltage quadrupling circuit of the flyback type is used almost universally to provide this voltage. It is relatively safe, inexpensive and uses the same standard components as were described in the preceding section for the single rectifier tube flyback type supply.

Figure 12-14 shows a flyback power supply used to quadruple the voltage obtainable from a single tube rectifier. The components V_5, T_1, V_1 and C_1 are basically the same as those in Figure 12-12 and if used without the remainder of the components shown, would provide an anode voltage output of approximately 7 kv. Tubes V_2, V_3 and V_4 with their associated components are added to quadruple the 7 kv. The operation of this circuit is as follows:

As in the case of the kick or flyback supply just discussed, a positive pulse is formed in the plate circuit of the horizontal sweep output tube, V_5, during the retrace or flyback period of the horizontal sweep cycle. Through auto-transformer action of T_1, this pulse is stepped up, in this case, to approximately 7 kv. This peak pulse voltage is represented in the circle in figure 12-14.

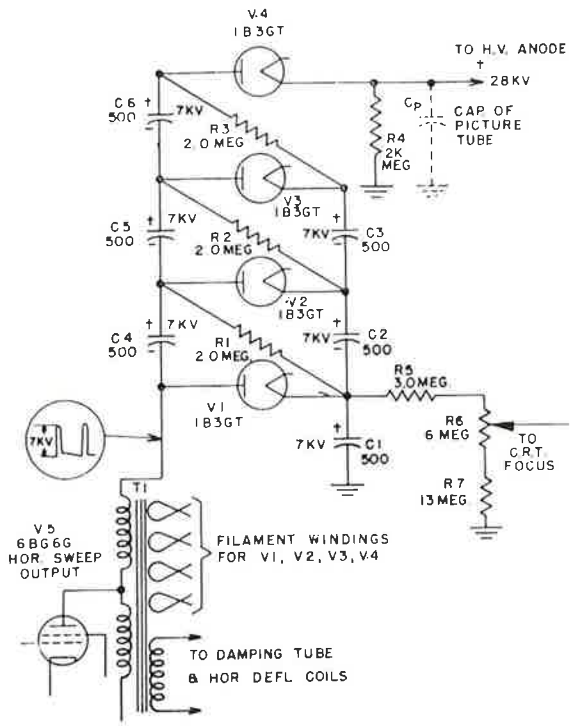


Fig. 12-14. 28 kv high voltage power supply.

Considering the first rectifier tube, V_1, this tube will conduct on these positive pulses which occur during the retrace period and charge C_1 to the peak value of these pulses or to 7 kv. The polarity of the charge on C_1 will be as indicated, with its lower or grounded plate negative and its upper plate positive.

Since the lower plate of C_4 returns to ground through the primary winding of T_1 and the B+ power supply, C_4, is in effect connected in parallel with C_1 through R_1. Therefore in-between voltage pulses (during the trace period of the horizontal sweep cycle) some of the charge on C_1 will gradually leak off and charge C_4. The charging path is through R_1, the primary winding of T_1, the B+ supply and to ground. The charge that leaks off C_1, in this manner, is replaced by each succeeding pulse until the charge on C_4 reaches the same value as that on C_1, which is 7 kv.

After C_4 becomes fully charged to 7 kv, it will result in an instantaneous voltage of 14 kv being applied to the plate of rectifier tube V_2. This is because the polarity of the charge on C_4 is such that it is series aiding with the 7 kv pulses. When tube V_2 conducts, it will place a potential of 14 kv across the series combination of C_2 and C_1. Since the capacitance of C_2 and C_1 are equal, then each capacitor will assume a 7 kv charge as indicated.

With the positive side of C_2 at 14 kv above ground, then, in between pulses, the high side of C_5 will gradually reach a potential of 14 kv above ground in the polarity shown, since it is connected to capacitor C_2 through R_2. After C_5 becomes fully charged, the total instantaneous voltage appearing on the plate of V_3 will be 21 kv. This consists of the 7 kv charge on C_4, plus the 7 kv charge on C_5 both of which are series aiding with the 7 kv pulses.

During conduction of V_3 it places a potential of 21 kv across the series combination of C_3, C_2 and C_1. Since the capacitance of C_3 is the same as C_2 and C_1 it will also assume a 7 kv charge. In between pulses, the high side of C_6 will gradually become charged to a value which is 21 kv above ground since it is connected to C_3 by means of R_3. After C_6 becomes fully charged, the total instantaneous potential appearing on the plate of V_4 will be 28 kv. This consists of the 7 kv charge on C_4, plus the 7 kv charge on C_5, plus the 7 kv charge on C_6, all of which are series aiding with the 7 kv pulses from the transformer.

During conduction of V_4 it charges the capacitor C_p, in its cathode circuit, to 28 kv. The capacitor C_p represents the capacity to ground of the high voltage anode of the picture tube.

By means of the quadrupling action just described, a voltage of 28 kv is thus available at the output of V_4 to be applied to the 2nd anode of the picture tube. In order to dissipate any charge remaining after the power supply is turned off, a very high bleeder resistance, R_4 (2000 megohms) is connected between the V_4 cathode and ground.

Since the anode current requirements for a projection tube is low, this supply may be designed with the same safety features as the supply described in the preceding Section 8. The filaments of the 1B3GT rectifier tubes V_1, V_2, V_3 and V_4 are supplied by a single turn separate windings about the sweep output transformer T_1.

The 5TP4 projector tube requires approximately 5000 volts for its focus first anode. This is provided from the output of the 1st rectifier tube V_1, and is made variable for focus control by using a high resistance bleeder circuit in series with the focus potentiometer R_6.

New RCA Releases

Radiotron 5814 is a "premium" medium-mu twin triode of the miniature type for use in many diversified applications including mixers, oscillators, multivibrators, synchronizing amplifiers, and numerous industrial control devices where dependable performance under shock and vibration is a major consideration. The 5814 has electrical characteristics similar to those of the 12AU7 but differs in having higher heater current and a lower heater-cathode-voltage rating.

Utilized in the 5814 is a compact structure designed to resist shock and vibration, a pure-tungsten heater to give long life under conditions of frequent "on-off" switching, a mid-tapped heater to permit operation from either a 6.3-volt or a 12.6-volt supply, and separate terminals for each cathode to provide flexibility of circuit arrangement.

Each 5814 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.

Radiotron 5840 is a "premium" sharp-cut off pentode of the subminiature type for use primarily as a broad-band rf or if amplifier in mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. It is constructed and processed to meet military requirements.

Featured in the 5840 is a compact structure especially designed to resist shock and vibration, a pure-tungsten heater to give long life under conditions of frequent "on-off" switching, and three leads to the cathode to permit isolation of the input and output circuit returns, and to reduce the cathode lead inductance.

Each 5840 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.

Radiotron 5719 is a "premium" high-mu triode of the subminiature type for use primarily as an audio amplifier in mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. In audio service as a resistance-coupled amplifier, the 5719 is capable of providing high voltage gain.

Featured in the 5719 is a compact structure designed to resist shock and vibration and to reduce microphonic output. A pure-tungsten heater is used to give long life under conditions of frequent "on-off" switching.

Each 5719 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.

Radiotron 12AQ5 is a beam power amplifier of the 7-pin miniature type intended primarily for use as the output amplifier of automobile radio receivers operating from a 12-volt storage battery. It may also be used in the output stage of ac-operated radio receivers.

The 12AQ5 can provide high power output because of its high power sensitivity and high efficiency. For example, in class A_1 amplifier service a single 12AQ5 operated with a plate and grid-No. 2 voltage of 250 volts can deliver a maximum-signal power output of 4.5 watts with a peak driving voltage of only about 12 volts. These features, together with relatively low plate-current drain, make the 12AQ5 especially suitable for use in the output stage of automobile receivers.

Within its maximum ratings, the 12AQ5 is the performance equivalent of the larger glass type 12V6-GT.