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COST vs QUALITY IN AUDIO

by John M. van Beuren

THE RADIO CLUB OF AMERICA

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PROCEEDINGS
of the
RADIO CLUB OF AMERICA

Volume 25 1948 No. 2

COST vs QUALITY IN AUDIO

By

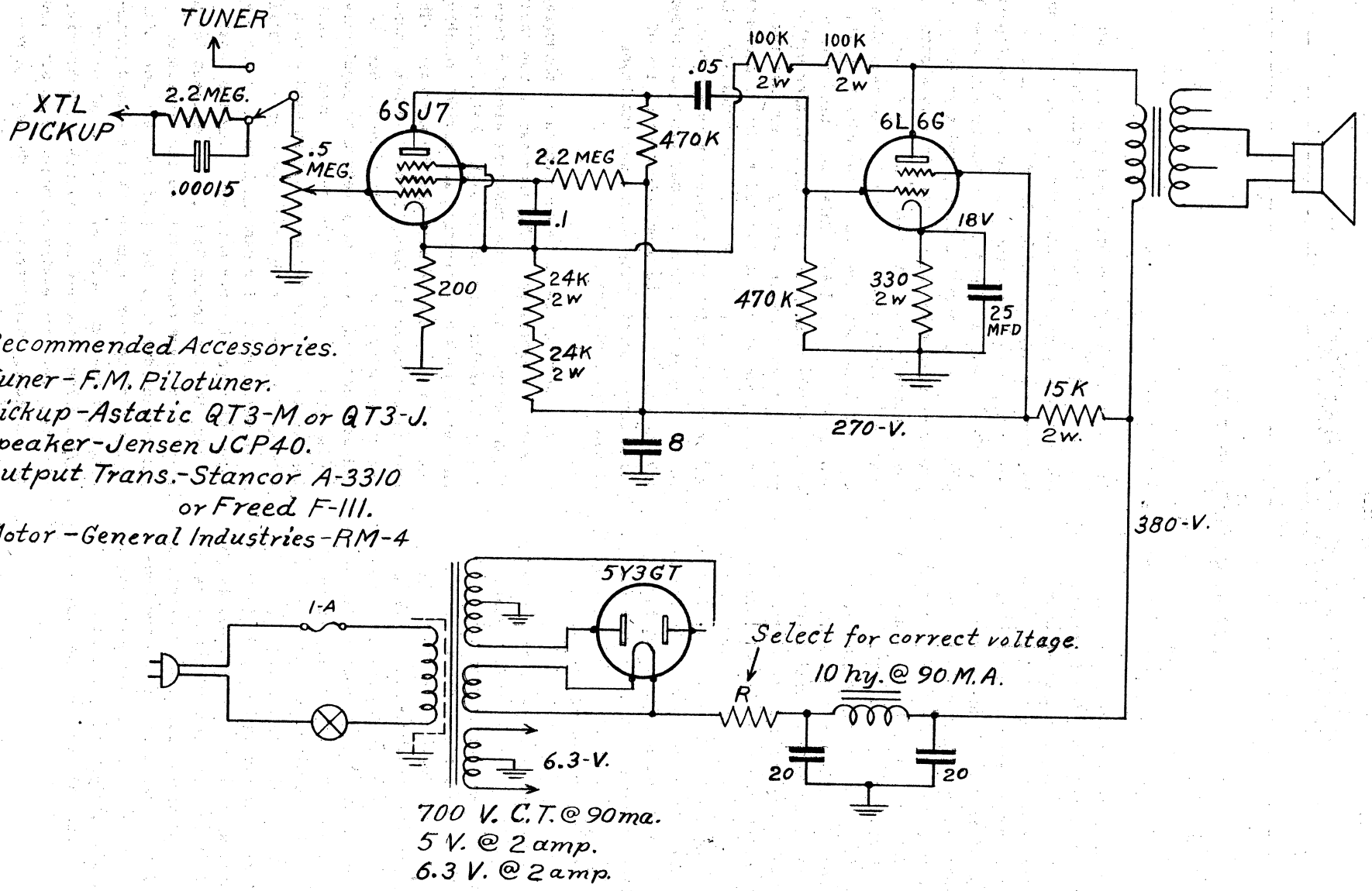
John M. van Beuren

No doubt almost every engineer has had the experience of being asked by some non-technical friend or acquaintance, "How much does it cost to own a high fidelity radio-phonograph?" That question can most easily be answered by asking how much the person is willing to spend for such an outfit. This paper has been written in an attempt to demonstrate how much audio quality costs, and how a given budget can be most wisely spent. The first statement that may be made is that reasonably good fidelity is not by any means expensive. The main cost of the average high priced radio-phonograph is in the cabinet rather than in the essential parts of the system. It is easy to demonstrate that good fidelity can be obtained at a minimum cost, and that excellent performance can be obtained at a somewhat higher, but still far from exorbitant cost. No claim is made that the amplifiers and systems to be described are the ultimate in quality, however, they will give the average listener a most satisfactory set-up at a cost that is within the means of almost everyone.

To return to fundamentals, any audio system contains three essential parts, namely, a source: which may be a microphone, a radio tuner, or a phonograph pick-up; an amplifier which raises the signal level to the proper value; and the speaker which reconverts the electrical power into acoustical energy. In the design of any system, it is important to correlate these three essentials into a unified whole. In keeping with the saying about "a chain is no stronger than its weakest link", no audio system is much better than its worst part. Consequently, there is little to be gained in combining an expensive speaker and a high fidelity FM tuner with an amplifier that contains a high degree of distortion or other undesirable characteristics. Since we are paying special attention to the economics involved in an audio system, we must consider the cost and ultimately the performance of each of the three essential parts of the final unit.

As a starting point, let us consider tuners. There are at present available on the market many types of tuners at many different prices. Some are for FM only, and some include both AM and FM. For a modestly priced system there is available an FM tuner selling for under $30.00 which gives a remarkably fine performance in the local metropolitan area. This combined with a phonograph, a small amplifier to be described later, and a medium priced speaker makes a very satisfactory system for the person who wishes to obtain pleasure from music at a minimum cost. There is also available at about $150.00 a tuner which includes both standard broadcast AM and FM. This, when used with a well designed amplifier and a good speaker with a proper enclosure, will satisfy even an exacting listener, and at a cost far below that of a commercial "high fidelity" receiver. Unfortunately, the market has recently been flooded by tuners both in the low and higher priced classes which fail miserably to live up to the manufacturer's claims of performance, sensitivity, etc., and the buyer should beware of these.

The next source to be considered is phonograph pickups and cartridges. The increase in popularity of phonographs in the home makes it almost a necessity to include one in any high fidelity outfit. Phonograph pick-up cartridges are divided roughly into two types, the crystal and the magnetic. The crystal cartridge has been standard in home phonographs for many years, and only recently has the magnetic cartridge enjoyed a return to popularity. It is capable of somewhat better performance than the crystal cartridge, though unless used with a very good system, the better type crystal is still quite satisfactory for general home use. The newer types of crystal cartridges employing the bent stylus, costing around $5.00, are excellent for use with the average commercial shellac pressings. Their main advantages are that they are not subject to hum pick-up from magnetic fields around phonograph motors, and their relatively high voltage output makes extra pre-amplification unnecessary. Likewise, they are easily compensated to suit modern recording characteristics. The maximum response, however, in the lower priced types is around 7,000 cycles which, while adequate for



Recommended Accessories.
Tuner - F.M. Pilotuner.
Pickup - Astatic QT3-M or QT3-J.
Speaker - Jensen JCP40.
Output Trans. - Stancor A-3310
or Freed F-111.
Motor - General Industries - RM-4

All capacitance in MFD.
All resistors ½ watt.
Unless otherwise specified.

FIG-1

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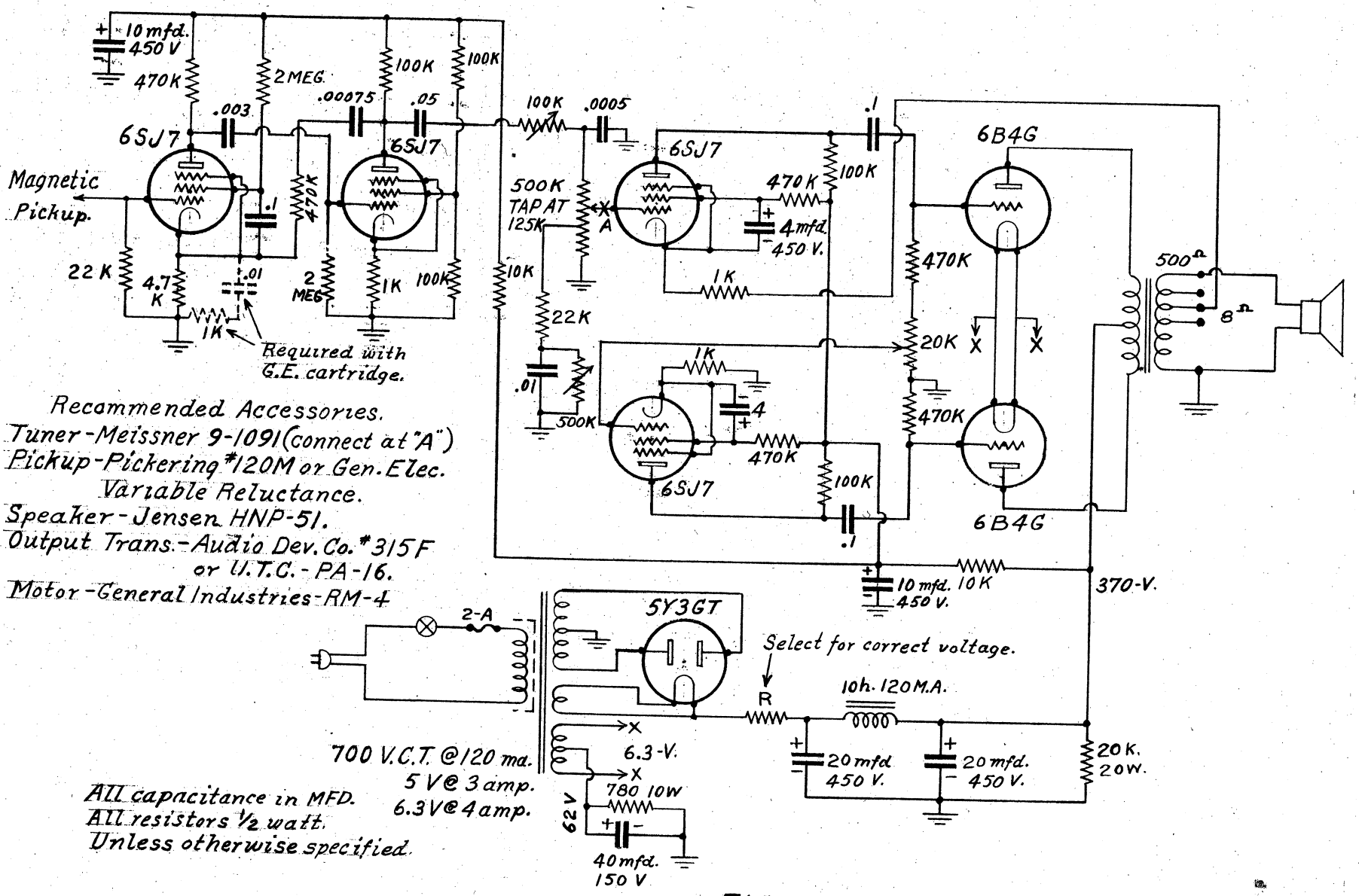
commercial shellac pressings, will not give the utmost fidelity. The magnetic cartridge has recently had a resurgence of popularity due to the fact that with proper design of the stylus and armature, it is possible to extend the frequency response to above the limit of audibility and to decrease harmonic and intermodulation distortion. Prices of these units range from around $5.00 to $15.00.

Due to the constant velocity characteristic of magnetic cartridges, a pre-amplifier employing compensation must be used with the cartridge to raise the response of the recording below approximately 500 cycles up to normal. The voltage output of the magnetic pick-up is usually considerably below that of a crystal pick-up, which makes necessary increased amplification. It is also very subject to magnetic pick-up of hum from fields around phonograph motors and record changers. One convenient device for greatly cutting down such hum and at the same time decreasing the natural rumble of the turntable, is to place on the turntable a steel plate approximately 1/8" thick and approximately 11½ to 11¾ inches in diameter. This quite effectively shields the pick-up magnetically, and at the same time adds considerable mass to the turntable thus decreasing rumble and wow. The steel plate may be covered with felt or flock in order not to scratch the records.

Before going on to describe amplifiers, let us consider for a moment loudspeakers and their associated enclosures. There are two general price classes for loudspeakers suitable for use in the home, around $20.00 and around $80.00. The $20.00 class contains both single cone radiators and duplex speakers consisting of a simple woofer and tweeter combination. While there are several speakers priced between the $20.00 and $80.00 classes, it is not felt that their performance is enough better than the lower priced unit to warrant spending the extra money. There are several speakers in the $80.00 class, however, one in particular gives excellent results. It consists of a 15-inch cone as the low-frequency unit and a coaxial exponential horn for the high frequency or tweeter unit. It has excellent high frequency coverage thru an angle of approximately 120° and its power handling capability is more than adequate for the home. It should be used with an amplifier having some bass boost as it is apparently somewhat lacking in bass response due to the fact that the low frequency resonance of the cone is very broad and smooth and the efficiency in the middle and high range is much greater than most speakers. However, it is judged to be considerably superior to comparably priced speakers which use a single voice coil to drive an outer cone for the lows and an inner dome-shaped diaphragm for the highs. There are several speakers priced considerably above the $80.00 class which offer even improved performance, however, it is felt that such price and performance are not warranted in the average home.

To insure good bass response no speaker should be used without a properly designed acoustical enclosure. Probably the most popular unit in present use is the vented or bass reflex enclosure. This is both simple to design and easy to construct and performs quite satisfactorily for average use. The dimensions are not overly critical and the unit can be shaped to fit in various spaces such as book-cases, under tables, etc. The approximate cubic content and size of the vent can be copied from commercial designs. Another excellent type of enclosure is the tuned resonant column or so-called labyrinth. This consists of a column with the speaker at one end and the other end open. The length of the column should be approximately 1/4 wave long at the resonant frequency of the speaker. It may be either straight or folded and should be damped with some acoustical material placed on the walls. However, care should be taken not to use too much damping material as a very dead and muffled response may result.

Let us now discuss the most important and undoubtedly the most controversial part of any audio system, namely, the amplifier. Economy is one of the standpoints of this paper, and these amplifiers are economical to build. Their performance, while not the highest possible obtainable, is still excellent and leave little to be desired from the point of view of the average user. From a standpoint of minimum possible expenditure, the amplifier shown on Fig. 1 should be of interest. It utilizes only 3 tubes, is of single-ended rather than push-pull design, and will deliver 3 to 4 watts output with less than 1% harmonic distortion. It is designed to work from a modern bent stylus crystal pick-up, and into a 12-inch coaxial speaker. The design is simple and straightforward and the average constructor should have no difficulty with it whatsoever. While a power output of 3 to 4 watts may seem small, it is ample for the average home living room, unless extreme volume is desired. Approximately 14 db of negative feedback is used to lower the plate impedance of the beam tetrode output tube, and to improve and flatten the frequency response of the amplifier. On the basis of



Recommended Accessories.
Tuner - Meissner 9-1091 (connect at "A")
Pickup - Pickering #120M or Gen. Elec. Variable Reluctance.
Speaker - Jensen HNP-51.
Output Trans. - Audio Dev. Co. #315F or U.T.C. - PA-16.
Motor - General Industries - RM-4

All capacitance in MFD.
All resistors ½ watt.
Unless otherwise specified.

FIG-2

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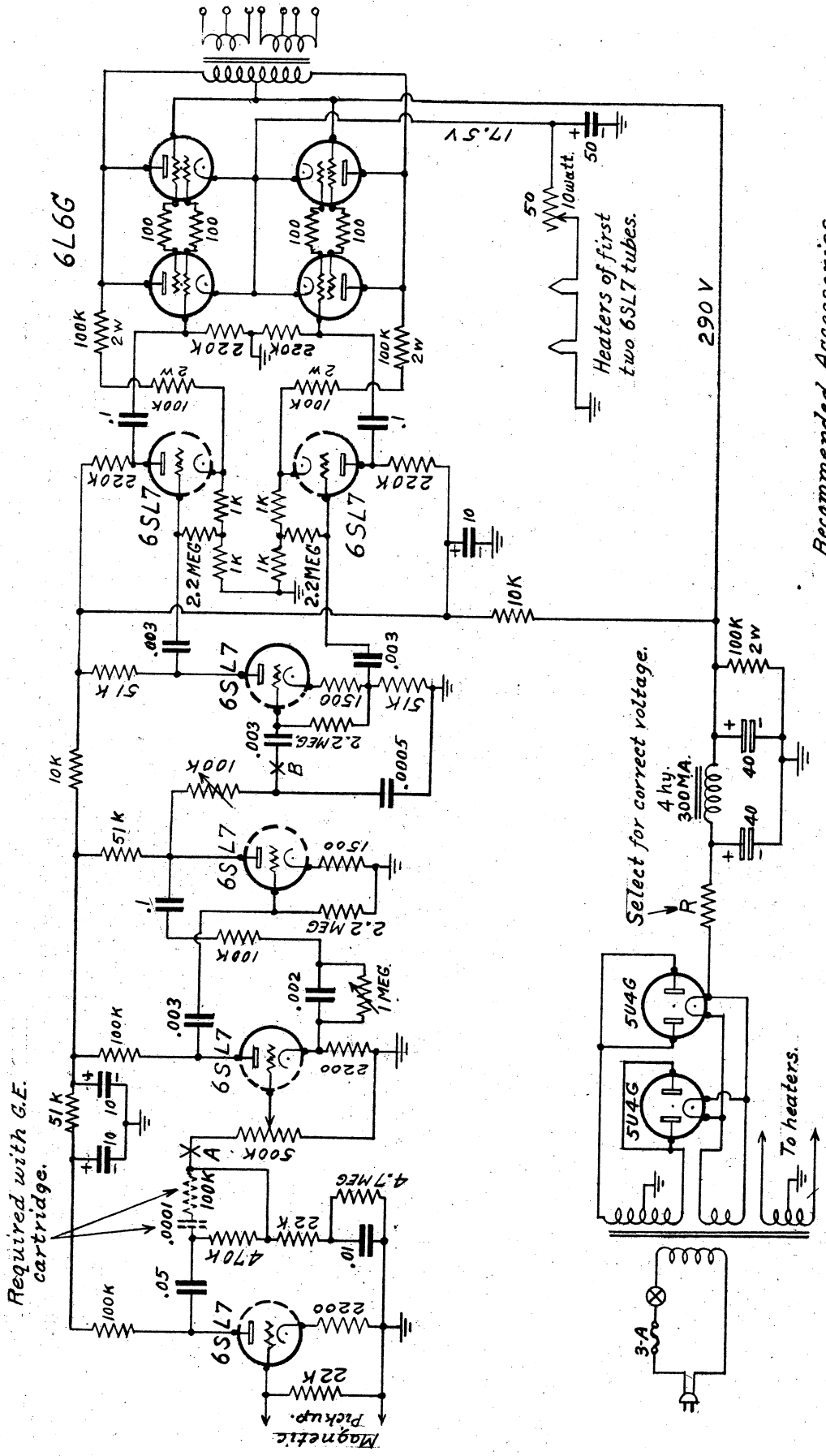
keeping costs low, no boost or attenuation circuits have been provided, however, record scratch may be attenuated by using the high frequency control on the speaker recommended.

The amplifier shown in Fig. 2 uses push-pull triodes in the output stage. Under the conditions shown it will deliver 8 to 10 watts of audio at less than 1% harmonic distortion and with low intermodulation distortion. Feedback in this case is taken directly from one of the voice coil windings and applied to the cathode of the driver tube. The design of this amplifier is straightforward and a considerable number of them have been built and used successfully. The pre-amplifier and input circuits deserve some mention. Designed to work from a magnetic phonograph cartridge, they contain the proper compensation circuits to raise the bass response to the proper level. This is accomplished by the use of negative feedback which decreases as the frequency decreases below the turnover point of approximately 500 cycles. Pentodes are used for the pre-amplifier tubes to provide the relatively high gain required, as it takes somewhat more than 5 volts to drive the final amplifier. At the output of the pre-amplifier are placed the high attenuation and bass boost circuits. High attenuation is accomplished in a somewhat unconventional manner by an RC network in which the variable resistance is in series and the capacity in shunt. This gives a roll off characteristic rather than the shelf type of characteristic obtained from the usual tone control. Bass boost is accomplished by using a tapped gain control. The tap at 125,000 ohms is loaded rather heavily by a 22,000 ohm resistor in series with a .01 condenser. Control is obtained by a 500,000 ohm variable resistance shunting the .01 condenser. As this resistance is increased the reactance of the .01 condenser increases at the lower frequencies, decreasing the shunting on the 125,000 ohm tap. If it is desired to use this amplifier with the tuner recommended, the pre-amplifier circuit may be ignored and the output of the tuner connected to the amplifier at point A. Since treble attenuation and bass boost circuits are contained in the tuner, these may be eliminated. However, if it is desired to use a magnetic cartridge with the tuner, a single stage pre-amplifier such as the first stage shown on Fig. 3 may be used. It is necessary to remove the compensation from the phonograph position in the tuner, as this compensation is designed for a crystal pick-up and should not be used with the magnetic type.

The third amplifier to be described is somewhat more complex and is capable of considerably greater power output. Approximately 25 to 30 watts are obtainable with under 1% harmonic distortion. This amplifier uses beam tetrodes in push-pull parallel in the output stage. Again, considerable feedback is used to reduce the plate impedance of the output tubes and to flatten the response. Overall feedback from the voice coil is not recommended with these particular types of tubes, due to the fact that it is rather difficult to prevent oscillations and poor transient response unless the primary is rather heavily damped by an RC network, which begins to load the primary rather heavily above 10,000 cycles. The pre-amplifier consists of a single triode with proper compensation in the output. Bass boost is obtained by use of frequency selective negative feedback in the second and third stages. Hum is reduced to the vanishing point by making the heaters of the first two double triodes part of the cathode resistor of the output stage. The output stage draws approximately 300 milliamperes which is the correct current for the heaters of the type 6SL7 tubes, and the additional bias required for the output tubes is obtained by a resistor. In the case of each of the amplifiers described, the power supply input resistor "R", which may vary from zero to 1,000 ohms, should be determined by experiment to give the proper operating voltage.

Now let us consider the cost of the various amplifiers described and their associated accessories. At current over-the-counter prices the amplifier described in Fig. 1 can be built for approximately $15.00 including tubes, chassis and miscellaneous hardware. The output transformer and loudspeaker add approximately $23.00 and a simple bass reflex enclosure costing less than $5.00 for materials can be built in a few hours. An excellent phonograph motor and an arm containing the recommended crystal cartridge can be obtained for an additional $20.00, or if desired, a record changer may be substituted for these items. For approximately $30.00 additional, FM may be added. Unfortunately, at the time of writing there does not seem to be available on the market an AM tuner comparable in price and performance to the recommended FM tuner. However, for the expenditure of approximately $90.00, the user may have an FM radio-phonograph that is superior to commercial models selling for four hundred dollars or more.



Recommended Accessories.
Tuner - Meissner 9-1091 (connect input at "A" and output at "B")
Pickup - Pickering #120M. or G.E.
Speaker - Jensen HNP-51.
Output Trans. - Audio Dev. Co. #315G or U.T.C. - PA-17.
Motor - General Industries - RM-4

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FIG-3

The second amplifier described can be built at current prices for less than $40.00 including the recommended output transformer. The phonograph motor, pick-up and speaker add approximately $100.00 more to the cost, giving for less than $150.00, a phonograph capable of reproducing the best records available today. For approximately $150.00 additional, the recommended AM-FM tuner may be obtained, thus giving for less than $300.00 a complete outfit, that is superior to commercial radio-phonographs selling for upwards of $1,000.

The amplifier shown in Fig. 3 can be built at a cost of approximately $60.00 to $70.00. The recommended accessories are the same as shown in Fig. 2 and need not be discussed further.

No mention has been made in this paper of cabinet space. Second-hand cabinets can be obtained very reasonably in most cities if a conventional cabinet is desired. What may be a better solution to the problem is to build the tuner, amplifier, and even the speaker into the furnishings of the house. Almost every home has enough bookcases or shelf space to contain the amplifier and tuner, which may be concealed by a simple plywood panel. The speaker may be built into a windowseat, a bookcase or even placed in the walls of rooms. Thus by the exercise of a little ingenuity, the cabinet problem may be solved economically and attractively.

In this paper it has been the author's intention to show that excellent audio performance can be obtained at a very reasonable cost. It is always somewhat of a shock to look behind the imposing cabinet of a $400.00 radio and find an inadequate chassis, an output transformer weighing a pound or less, and a 6- or 8-inch loudspeaker. The performance of such a receiver compares miserably with even the cheapest outfit described in this paper. When one considers the tremendous savings of mass buying and mass production, it is disappointing to say the least, that the purchaser of a radio does not receive more for his money. Any manufacturer who gave slightly more consideration to the design of his amplifier, and invested only slightly more in the output transformer and speaker could give the public a really satisfactory radio-phonograph combination at an increase in price of only a few dollars over current models. Let us hope that public demand for decent audio quality at a reasonable price will force shortsighted radio manufacturers to abandon their present policy of inadequate design and concentration on looks rather than performance.

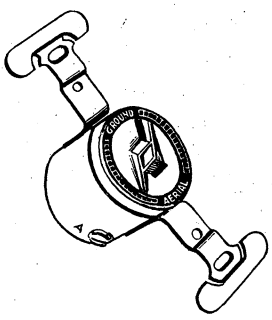
ARMSTRONG MEDAL AWARDED TO THE LATE STUART BALLANTINE PRESENTED TO MRS. STUART BALLANTINE

Describing the late Charles Stuart Ballantine as one of the world's most versatile engineers, Major Edwin H. Armstrong presented the ARMSTRONG MEDAL to Mrs. Stuart Ballantine at her home in Boonton, New Jersey on Saturday, June 26th.

The Radio Club of America, doner of the medal, announced the post-humous award last December at the 38th Anniversary Banquet of the Club.

Professor Alan Hazeltine, Lawrence C.F. Horle, Harry W. Houck and Major Armstrong represented the Radio Club at the presentation ceremony.

THE ARMSTRONG MEDAL



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● **Designed, developed and engineered by Amy, Aceves & King, Inc., and manufactured by licensees. Literature on request.**

The Multicoupler Antenna System is thoroughly covered by basic and detail patents owned by Amy, Aceves & King, Inc.

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The Arrow-Hart & Hegeman Electric Co., Hartford, Conn., offers all necessary equipment such as installed in the apartment-house developments herein referred to.

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Model 71

SPECIFICATIONS:

FREQUENCY RANGE:
Continuously variable from 5 to 100,000 cycles per second.

WAVE SHAPE:
Rise time less than 0.2 micro-seconds with negligible overshoot at 75 peak volts output. At 5 volts or less, rise time is 0.15 microseconds.

OUTPUT VOLTAGE:
Step attenuator giving 75, 50, 25, 15, 10, 5 peak volts fixed and 0 to 2.5 volts continuously variable.

OUTPUT IMPEDANCE:
20 ohms per volt.

SYNCHRONIZING OUTPUT VOLTAGE:
25 volts peak.

SYNCHRONIZING OUTPUT IMPEDANCE:
1500 ohms.

SYNCHRONIZING INPUT IMPEDANCE:
Over 20,000 ohms.

R.F. MODULATOR:
5 volts maximum carrier input. Transition gain is approximately unity. Output impedance is 600 ohms.

TUBES:
Two 6AG7's; three 6J5's; one 6SA7; one VR150/30; one 5Y3G.

POWER SUPPLY:
117 volts, 50-60 cycles. Self contained, no batteries. 100 watts.

DIMENSIONS:
7" high, 15" wide, 7½" deep.

NET WEIGHT:
Approximately 15 lbs.

NOTE: This instrument is self contained and does not require an external driving source.

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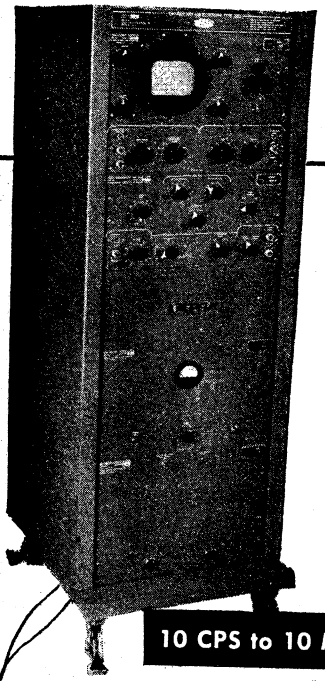
DU MONT *High-voltage Oscillography*

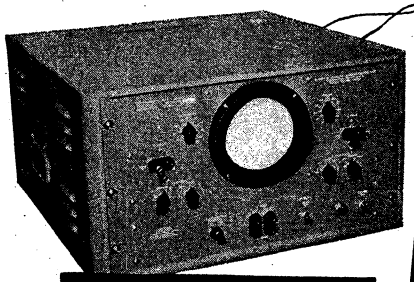
The basis is the Type 5RP-A Cathode-ray Tube operating at an accelerating potential up to 29,000 volts maximum. This achieves: (1) Greatly increased brightness; (2) Observation or recording of traces hitherto invisible; (3) Vastly increased writing rates even better than 400 inches per microsecond; (4) Optical magnification by projection lenses such as Du Mont Type 2542. Although deflection sensitivities are slightly less than those of low-voltage cathode-ray tubes, high-voltage oscillographs produce smaller spot size and higher brightness, thereby presenting a finer, better resolved trace.

And here's the Du Mont selection of high-voltage oscillographs:



10 CPS to 10 MC

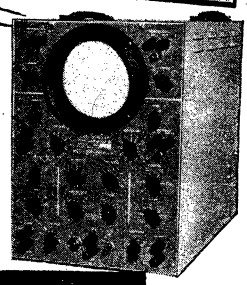
Type 280: A precision time-measuring oscillograph with range of 10 cps to 10 mc. Sweep speeds as high as 0.25 microsecond/in. are available. Duration of any portion of signal measured on 0.25 microsecond/in. sweep to an accuracy of ±0.01 microsecond. Intervals greater than 5 microseconds read on calibrated dial to accuracy of ±0.1 microsecond. Ready application to precise measurement of duration of waveform of various components in the composite television signal. Accelerating potential adjustable from 7,000 to 12,000 volts. Recordable writing rates up to 63 inches per microsecond, with commercially available equipment.



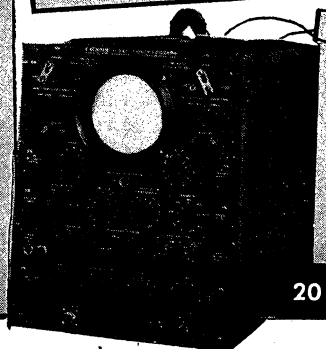
WRITING RATES TO ABOVE 400 IN./MSEC.

Type 281-A: Devoid of internal deflection amplifiers, there are no frequency response limitations within the ratings of its Type 5RP-A tube. Phenomena have been recorded photographically at writing speeds of 85 inches per microsecond. With external power supply (such as Du Mont Type 286-A), photographic writing speeds of over 400 inches per microsecond may be examined. Recommended when oscillographic needs are extremely specialized or too advanced for standard commercial equipment. An accelerating potential as high as 29,000 volts is available with the Types 281-A and 286-A in combination.

Type 250-H: Covers range from d-c to 200 kc. Potentials containing both d-c and a-c components may be examined. Many special features for general usage include: linear time-base of unusual flexibility; automatic beam control on driven sweeps; internal calibrator of signal amplitude. This is a high-voltage oscillograph with maximum accelerating potential of 13,000 volts. Recordable writing rate of approximately 40 inches per microsecond.



D-C to 200 KC



20 CPS-5 MC

Type 248-A: Frequency range of 20 cps to 5 mc. Specifically intended for investigation of pulses containing high-frequency components of recurrent or transient nature. For this purpose it provides these necessary characteristics: High-frequency recurrent sweeps; short-duration driven sweeps; timing markers; signal delay network. Accelerating potentials up to 14,000 volts at recordable writing rate of approximately 69 inches per microsecond.

LITERATURE ON REQUEST

DU MONT *for Oscillography*

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