ly larger total loss in the larger core. It would be well to point out at this time that for 6L6 tubes operated in Class AB or Class B, the ratio of inductive reactance of the primary of the output transformer to the leakage reactance between the primaries must be 80,000 to one or greater to permit 1 per cent distortion at 20 kcs and full output to as low as 20 cps.

From the above discussion it seems impractical to reduce the leakage reactance sufficiently to permit high-efficiency operation and the only hope, therefore, is to go back to a conventional Class A arrangement where a discontinuity in the current drawn by each of the tubes does not occur over the operating cycle. The solution for high efficiency operation requires an unconventional circuit which will effectively eliminate the leakage reactance between the primary windings.

*Figure* 5 illustrates the approach made to circumvent the problems described above. The conventional output primary circuit is again shown with the primary marked *2* in dotted form. For simplicity the power supplies are eliminated and the midpoint of this primary is shown connected to the associated cathodes. The solid position of primary *2* is shown adjacent to primary *1* and this illustrates the first step in the development of the unity coupled amplifier. These two primaries are wound

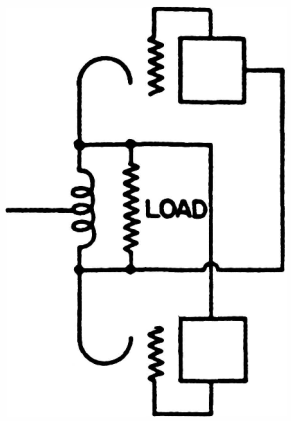


Fig. 8. Equivalent circuit simplified from Fig. 7.

together in a bifilar manner as if they were one winding and, therefore, there is between them both a capacitance coupling turn by turn, and a magnetic coupling due to the presence of the common core. Since the wires occupy practically the same space, the coupling is exceedingly high and measurements show that it is practicable to wind coils with a ratio of primary inductance to leakage reactance much better than 200,000 to 1. This, therefore, provides a way to eliminate the leakage reactance which in conventional transformers far exceeds the minimum ratio requirement of 80,000 to 1. We now, therefore, have a system which appears to have promise by reason of finding a way to eliminate the leakage reactance between the primary windings which in turn removes the barrier which has blocked for so many years the use of high-efficiency circuits in high quality audio amplifiers.

It is obvious that other variations of approach have been considered which accomplish the desired purpose to some extent at least, such as winding the two primaries on a common core not bifilarly and utilizing a suitable capacitance for couping the ends of these windings so as to maintain the two windings at proper and identical a.c. potentials. One advantage of the bifilar winding is, of course, a reduction of the number of components required, and it sidesteps some of the difficulties which grow out of the use of alternate approaches. It may also be obvious here that since the two primary windings are unity coupled there is no longer any need for sectionalizing the primary as is common in high quality transformers today. This results in an economy in manufacture.

**Circuit Arrangement**

To make *Fig.* 5 a practical circuit, the cathodes are connected to one coil and the plates to the other coil without changing their position in the circuit from an a.c. standpoint but permitting

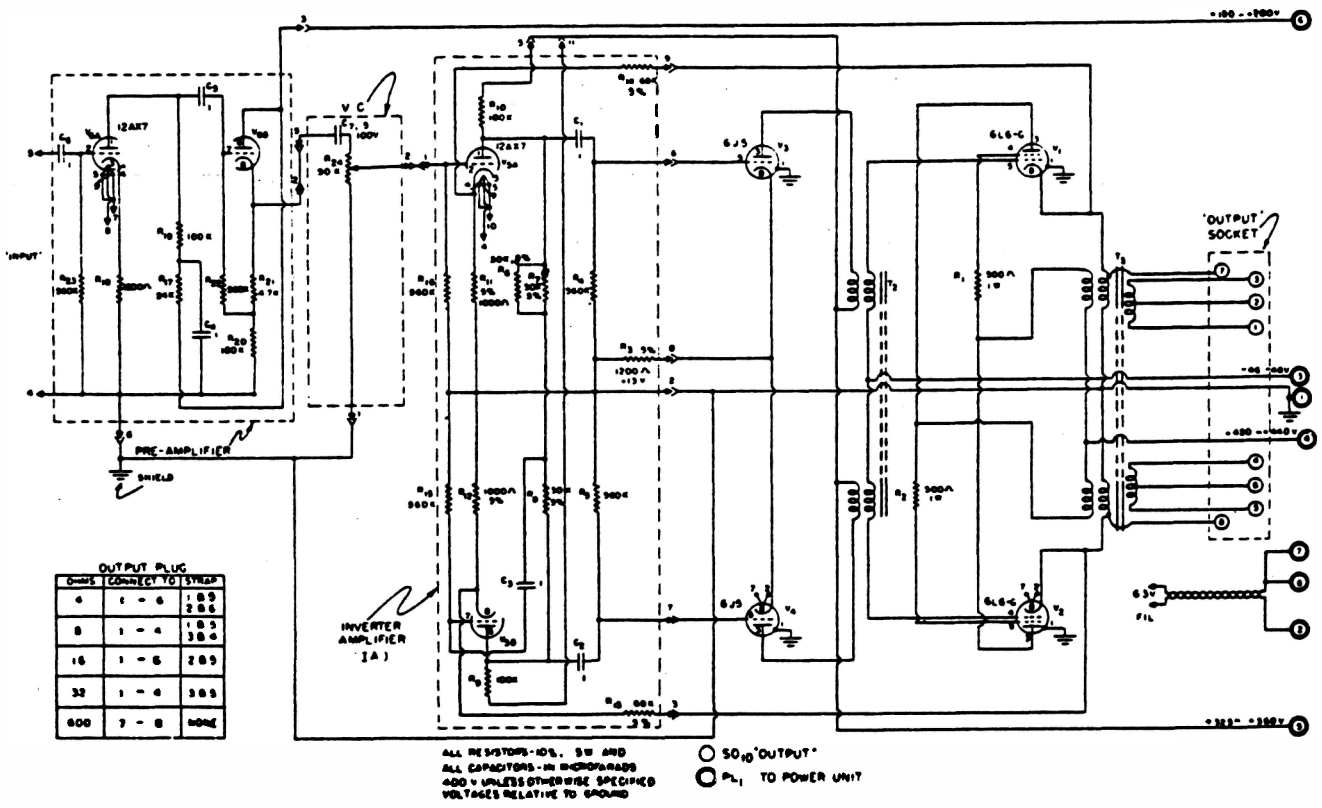


Fig. 9. Schematic of McIntosh 50W-1 amplifier.