only is the system less expensive to buy in the first place (about half the cost of existing equipment), but day-to-day operational expenses are cut dramatically by about 90%.

There are other factors that should be considered. Synchrolock machines run so quietly that there is no need for the mixing station to be isolated from the machinery. The Synchrolock tape system needs no special electrical installations; any convenient outlet for 117-V house current will serve nicely. It is so compact that the "sound department" may be set up almost anywhere in a few minutes and stored in a closet when it is not in use.

For the filmmaker on a budget, the Synchrolock system opens new vistas of creativity in sound. If first results are any indication, ¼-in magnetic tape, in this new and original application, may well become a serious competitor of 16mm sprocketed magnetic sound film.

Technical Note

Outboard Transformers for Audiovisual Equipment

By RAYMOND WYMAN

About four years ago, the author proposed that 24 V should be the standard voltage for operating audiovisual equipment. Several benefits of such standardization were considered: increased user safety, international compatibility, more portable equipment, more efficient optical systems, possibly lower cost equipment, and use of equipment in places that lack electrical mains. Now, it is pointed out that many of the good new audiovisual systems do employ built-in transformers to reduce the mains voltage to an optimum level for projection lamps and solid-state electronic components. The disadvantages of inboard transformers, however, are that they add substantially to equipment weight, often constitute a source of hum in audio circuits, and still require that a potentially dangerous higher voltage be supplied to the machine. It is noted that a number of electrical products for the consumer are equipped with outboard transformers — sometimes as options; tape recorders and pocket calculators are examples. It is recommended that the next generation of audiovisual equipment should also employ outboard transformers to provide the benefits envisioned earlier. Questions involving connector standardization, current rectification, grounding, centertapping, etc., are examined.

The effective use of audiovisual equipment for education and training is well established throughout the developed countries of the world and is eagerly anticipated by the developing nations as a major means for improving their education and training. Practically all of this equipment operates on electricity, but there are major differences and problems that inhibit widespread use.

Transformers are regularly used *inside* modern higher quality audiovisual equipment in order to change the voltage of the mains to an optimum lower voltage for projection lamps and solid state electronic components. These integral transformers make audiovisual equipment heavy due not only to their own weight but also to the weight of the frames and cases needed to support them. They may also induce hum in audio circuits unless special shielding is used. Integral transformers also mean that mains voltages are carried into the machines and probably fused, switched and interlocked in a device that is often in contact with children and subject to all kinds of abuse. Maintenance operations such as cleaning and lamp replacements may expose people to mains voltages. The mains voltages that are optimum for electrical distribution in a building have nothing to recommend them for audiovisual equipment operation.

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In the *Journal* of June 1973, the author proposed the adoption of 24 V as the universal operating standard for audiovisual equipment. Now, we move on to propose more specifically the universal adoption of outboard transformers with standard electrical characteristics and standard connections. Outboard transformers in smaller sizes, perhaps to 100 W, could have integral pins or blades to fit directly into power points such as duplex outlets. The countless outboard transformers currently used with calculators and tape recorders attest to the feasibility of this approach. Unfortunately, the great variety of connectors, voltages and frequencies for these small devices create much confusion. Transformers in larger sizes up to perhaps 250 W could be attached to walls and projection stands or allowed to sit on the floor. Our proposal does not affect equipment such as opaque projectors and auditorium projectors requiring large amounts of power; they would probably continue to be operated on mains voltages.

Safety is of the utmost importance in regard to audiovisual equipment. Consider that operators who are often unskilled handle it, move it frequently and sometimes even combine it or interconnect it with other pieces of electrical equipment. Use of outboard transformers exclusively would guarantee that only low and safe voltages would ever come in contact with the operators.

Portability is another major consideration. Many teachers and trainers find it impractical to use equipment that is too heavy to lift easily. The removal of the power transformers would make many machines such as motion-picture projectors far more attractive to use. The outboard transformers could be carried separately or preferably left permanently where they are regularly needed.

Efficiency is another factor. Low-voltage projection lamps with much smaller light sources are so much more efficient in getting rays through the optical system that the wattage is typically reduced drastically. Current 16mm motion-picture projectors with integral transformers and low-voltage lamps put as much light on the screen with 250-W tungsten-halogen lamps as mains-operated machines do with common 1000-W tungsten lamps. Another factor relating to efficiency is image resolution. It is evident that a smaller light source increases image sharpness. Some overhead projectors with low-voltage lamps and two-element projection lenses seem to produce images as sharp as other projectors with mains voltage lamps and three-element lenses. The additional costs for external transformers might be offset by using less expensive lenses.

Manufacturers and users alike should benefit if standard AV equipment is used more widely throughout the world. A variety of outboard transformers with different power ratings could be designed for use on 120 or 240 V and either 50 or 60 Hz. This could be easily done with two primary windings that could be connected either in parallel or in series by means of a switch or internal connection. Many transformers used with calculators and tape recorders already make use of this feature, and they can be used almost anywhere in the world. Adaptors for the various plugs would be needed.

There is still the problem of alternating-current frequencies and direct current. This could be easily solved by requiring that all low-voltage AV equipment operate equally well on 50-60 Hz and direct current. If only lamps are involved, then rectification is not needed. Motors could be ac/dc or dc-only and equipped with a rectifier and filter. Electronic equipment

would require an integral rectifier and filter. This system would permit almost universal use of standardized equipment.

A standard secondary voltage would obviously be required. There seem to be several advantages to making it a centertapped 24-V. Twenty-four volts is generally accepted as the highest ac voltage that does not require special precautions, and many electrical code requirements are built around this voltage. The resulting dc voltage might go up to about 30 V, which is still considered safe. Twelve amperes at 24 V would easily provide for a 250-W lamp, motor and amplifier for the most complex and highest power equipment ordinarily needed in education and training outside of large auditoriums. This should be compared with the 12 A presently needed for a sound movie projector with a 1200-W lamp operating on 120 V. In other words, about the same size wire would be needed between the outboard transformer and the equipment that is now used between the power point and the machine.

The centertapped system would permit and encourage complementary or push-pull electronic circuitry, which has proven advantages. It would also permit the reversing of 12-Vdc motors for rewinding and reverse operation as well as for braking purposes.

The availability of 12 V from the secondary would encourage the uses of equipment made in large volume for auto and trailer use. The range of 12-V electrical lamps and other apparatus is very wide. Since such equipment was designed for mobile use, it is also very robust and usable in a variety of environments.

Twelve-volt equipment could easily be used on an auto storage battery and 24-V equipment could be used with two batteries in series. Many trucks already operate on 24 V and use a mixture of 12- and 24-V equipment. The implications of this power source for developing countries and remote areas are great.

Twelve-volt zinc, alkaline and dry rechargeable batteries are not now common although they are used in some dictation equipment. Perhaps an existing 12-V battery should be adopted or a new one developed. One battery alone would suffice for 12-V AV equipment, while a pair of them would serve for higher power equipment. Obviously only relatively low-powered equipment would be operated from dry batteries.

A series of standard outlets or connectors on the outboard transformers and batteries or battery packs would need to be adopted or developed. It should be possible to mate any proper combination and impossible to mate any improper ones. This would require careful study and experimentation but should not be too difficult.

There is some question about whether a maximum of three or four wires and contacts would be needed. Some equipment such as viewers or simple recorders need only two wires for 12 or 24 V, while other systems would need three wires for the centertapped feature. The centertap might or might not be grounded. A separate ground that normally carries no current might be desirable. These are engineering and design matters that must be decided by professionals.

It seems that studying this matter and standardizing on AV equipment with outboard transformers could produce very worthwhile results. The new generation of equipment that results would be safer, more portable, more efficient, more universal throughout the world, and more easily maintained and used.

The proposal is on the table. Now, will the industry respond?