

THE RE-RECORDING OF WAX CYLINDERS¹

Foreword

Since Dr. J. Walter Fewkes, late Chief of the Bureau of American Ethnology in Washington, first, in 1889, realized the possibilities of the then newly invented phonograph for making collections of the songs of American Indians, his example has been followed in scores of field expeditions. As the years went by, the quaint and clumsy old phonograph, which was run with a treadle and had a fly wheel for regulating the speed, was superseded by other improved models, until the later Dictaphones and the Edison phonographs represented the ultimate development of non-electrical machines using wax cylinders for recording sound. Electrically operated machines using wax cylinders, though still employed in business offices for recording correspondence, are not as satisfactory in several respects for field use and for recording music as were some of the old style gramophones.

In the various universities and museums in the United States, there have been collected during the past half century some 15,000 wax cylinders containing records of the music of various races, chiefly of the different tribes of American Indians. Some of these records are now priceless from a scientific point of view, since many of the tribes among which they were made have either become extinct or their culture is so changed by contact with European culture that their music has completely or practically disappeared.

It is surprising how good some of these records are, considering that their collectors were not musical specialists and that the conditions under which the records were made were often most unfavorable for good results, while the machines were relatively so simple or even crude.

Time, also, has its deteriorating effect on records, in the formation of a somewhat hardened surface or patina. This "crust" creates a rasping surface noise when the record is played again after long disuse. With some records this patina partly disappears after a few

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playings and the record greatly improves in clarity. With others nothing seems to help the condition, which differs with the various wax compounds and is only partly dependent upon age. Carelessness in handling the records when they were made, touching the recording surface with the fingers, often leaves traces in mildew spots (particularly if the records are kept in warm countries) which eat the surface of the wax so that in subsequent playings, when the reproducer passes over them, a knocking noise is heard that is easily confused with drum beats. Some old wax records have been considerably worn by playing. This is particularly apt to be true of those made on Edison phonographs with the finest grooving (200 threads to the inch) with correspondingly fine and sharp cutters. Fortunately this type of recording was fairly late and while some recent collectors have attempted to economize record space by using the finer grooving, their collections are not very large nor usually important.

The older and rarer material on records with coarse grooving (100-150 threads to the inch) not only have withstood wear in remarkable fashion, but for the most part are excellent in quality. However, they are wax, brittle and easily cracked or broken, and they do wear with repeated playing. Even where curators did not realize these facts sufficiently to take active steps to protect the records from indiscriminate handling, fortunately the playback on the old machines was such as to discourage the free use of records. So most collections have lain neglected, covered with dust. The old type cylinder machines, in America at least, have become scarce with the advent of the disc-playing phonographs which use a lateral cut rather than the "hill and dale" method employed in recording on cylinders. Such cylinder machines as are still to be had are becoming difficult to keep in repair, since spare parts are now almost unprocurable.

It seems only yesterday, although fifteen years have slipped away, that, confronted with rapidly wearing cylinders which were faint to begin with, and hoping for some help that would make transcribing less of a frustration, I wrote Mr. Edison of my difficulties and was invited over to his laboratory for a conference. It is hard to realize today that at that time radio amplifiers were still not perfected and that his answer to my question as to whether there were not some way to copy off the sound on to discs and to amplify it, was that this would involve some of the most difficult problems in the field of sound engineering and that amplification lay in the future.

Vast developments have come about in the last decade, chiefly as the result of radio. Following the old phonographs of thirty years ago came the disc models, and with radio the loud speakers, now a

regular part of every modern electric phonograph. Various recording machines have been put on the market, using aluminum discs and intended for commercial and home recording. While they were a great advance over old methods, and each had some good features, they all offered serious drawbacks — of weight, size, complex mechanism, not too faithful recording, particularly for speech sounds and individual voice quality, and not least important, initial price and cost of operation. It was obvious that they could not be used in field collecting and those that were later designed for this purpose by various companies, who discovered there was no great commercial demand for them, were still too heavy, impractical and generally unsatisfactory.

With motion pictures came the possibility of filming sound by various means, or using synchronized records. Several machines were devised, but all were prohibitive in price for scientific work, and, where the method of photographing sound waves was used, the difficulties of analyzing these into pitch and words were almost insuperable. After inspection of each I sadly, yet gladly, went back to the old cylinder machines. But the problems of the wax cylinders still remained, growing greater with time and with the increasing interest in comparative musicology, for we were reluctant to play for study and hence spoil, to some degree, the only originals we had.

A problem of transcribing some songs of primitive Central Brazilian tribes, brought back on talking motion picture film, involved what is technically known as "dubbing" a sound from film to records and, fortunately, put me in touch with The Sound Specialties Company of Waterbury, Connecticut. There I at last discovered that machines which the most recent developments in sound engineering made possible, but specially adapted to our problems, could be built at moderate cost. Sufficient funds were secured through the generosity of the Carnegie Corporation and together Mr. Thompson and I planned the equipment, I stating the needs and requirements and checking performance as he solved the engineering problems.

Only bare mention need be made here of a field recording outfit that was perfected, using aluminum discs and recording electrically through a microphone, where the chief considerations were efficient recording and portability. The machine is in two units, roughly the size and weight of two full suitcases. Since collectors of primitive music go often to places where electric current is non-existent and where automobiles cannot penetrate, the motor for driving the turntable is spring wound, as in the old phonographs, but with a steadier movement and much more power. To have it electrically driven

would require too many dry cell batteries, or a storage battery, adding excessive weight and liable to rapid drainage. But the amplifier is operated by dry batteries. A play-back permits hearing the record with ear-phone, sufficiently to gauge whether the recording is satisfactory.

Even less need be said of a laboratory play-back phonograph built with loud-speaker, which has as its special feature a device controlled by a button pressed by the foot, which lifts the needle from the disc, replacing it again several grooves back of the point where it was lifted, so that a given passage may be played over and over, either in lecture demonstrations or by the transcriber whose hands are thus free to continue writing without interruption.

By far the most important machine is the heavy laboratory equipment for re-recording the wax cylinders. This machine will also record directly through a microphone from a singer in the laboratory, by simple additional attachments, and will play back either the cylinder or disc records with loud-speaker. But its chief business is to copy the sounds on the cylinders by means of very delicate electric pickups tracking in the "hill and dale" grooves, from which the sounds are conveyed through a pre-amplifier to the cutters which then trace the new grooves by the modern "lateral cut," on to discs of a more permanent material which can be played a reasonable number of times without appreciable wear.

[Helen H. Roberts]

A re-recording process such as outlined above should meet many requirements. The reproducer or pickup which engages the original wax cylinder should be of the utmost lightness in weight, and the stylus of a shape as to wear the cylinder far less than the ordinary phonograph reproducer, or not at all. It should travel more or less freely, suspended, so that it can follow slight differences in the number of threads to the inch which characterize records made on various machines. It should be capable of reproducing every iota of quality that was recorded on the cylinder, since the original recording was, at best, not technically perfect, due to the limitations inherent in the old machines. (Even so, when the originals were properly made, it is amazing how good the amplified product is.) The reproducing system of the machine should embody the means for adjusting the quality of sound picked up to compensate as far as possible for its limitations.

Thus, if the original tone lacked the higher harmonics, due to faulty recording, the reproducing system should preserve and even amplify such higher harmonics as do exist. Or, if there is considerable surface scratching noise incident to playing over the hardened surface or patina after considerable lapse of time (which noise lies in the higher frequencies), there should be compensation for this defect rather than excessive amplification of it. Again, some old recorders were sensitive enough to catch the rumble of the cog wheels and spring, recording them along with the music. These sounds fall in the lower frequency range and, although they would not be heard with the old reproducers, they are picked up electrically and greatly amplified by the new machines, creating another defect for which some compensatory provision is needed.

In order to assure minimum handling and wear of wax originals, it also seemed advisable to arrange for the production of three simultaneous identical copies. This had another advantage than a mere saving of time, for, being identical, one copy could be preserved, if desired, inviolate in archives for the future, one could be played for demonstration purposes in lectures, or for transcribing, and one could be used for a master in making additional copies.

It was also necessary to plan the machine so that, while playing a disc record on one of the three turntables, two identical copies of it could be made on the other two turntables, the cutting being carried on simultaneously. The disc records had to be reasonable in cost, relatively permanent and unwearable, for, otherwise, in handling thousands of records, the expense would be prohibitive for musicological work.

These requirements have been met as follows:

Two old machines of the cylinder type, a Dictaphone for long records and an Edison for the shorter ones, are mounted on a stand which also serves as a board for control switches and dials, and are connected electrically with the laboratory machine, by means of a switch which cuts out one or the other at need. The feed bar of the Dictaphone has 150 threads to the inch and the flexibility of the pickup travelling over it is such that it will satisfactorily play records having a considerable range of variation in threads to the inch, or, if the difference is too great for satisfactory tracking, feed bars with 100 or 200 threads to the inch may be substituted. The Edison machine is the compound type which may be adjusted so as to play either on a 100 or 200 thread to the inch scale, and thus to take care of all short length records, since apparently they were all of either one type or the other. However, the pickup on this machine is also flexible.

The pickups are permanently mounted on these machines in place of their original reproducers, with removable and replaceable styluses. It is essential that reproducers of this type should be electrical for best results, because their weight and the characteristics of their moving parts should not be limited by the necessity of generating any appreciable energy. Therefore an electrical reproducer based on the piezo-electric effect was made, which exerts an extremely low pressure on the wax cylinders, with moving elements of very low inertia and stiffness, and with a sapphire point which accurately fits the grooves on the record. Thus the originals (all but the very fine-grooved ones) may be played any number of times without serious wear. The reproducer is very faithful in the quality of sound reproduced and even the wax cylinders, when played with it through an amplifier, sound infinitely more natural than with the original reproducer and horn, while the re-recorded discs may be a great improvement even over these, by the judicious use of volume controls and sound frequency filters while cutting.

The electrical pickup or reproducer is connected into a high gain amplifier of unquestioned frequency response within the recognized limits of human hearing. The amplifier is equipped with two independent networks or filters, one of which cuts off the higher sound frequencies or vibrations, and the other the lower frequencies, by means of adjustable controls operated by knobs placed on figured dials on the operator's switchboard. The high-frequency cut-off begins at 2000 cycles and the attenuation can be made so complete that at 3000 cycles the response can be made negligible, if desired. The low-frequency cut-off begins at 400 cycles and the adjustment can be so set as to exclude practically everything at 150 cycles. In practice the low-frequencies are usually cut a little for all cylinders, and considerably for those with weak voice recordings which nevertheless carry excessive gear noises and rumbles from the worn old machines. Such noises are not usually audible when the records are played on the old cylinder machines, since they occur in a range where the original reproducers functioned hardly at all. The high-frequency cut-off is used most with worn, scratchy cylinders, or for weak recordings where the normal scratch is high compared to the level of the recorded material, or where there is a bad "crust."

Another control is that of volume, which is a knob on a figured dial, so connected with the amplifier that the operator may reduce or step up the amount of sound passing through the amplifier to loud speaker or cutters, depending on the needs for re-recording. Some weak records can be vastly improved by using the utmost volume, while blasted or over-loud ones can be rendered less objectionable

while still preserving sufficient loudness or contrasts. A switch for the loud speaker permits the operator to hear the record clearly as it is being played and cut or re-copied, so that he may accurately gauge the final result and plan out, even in advance, the proper combination of volume and frequencies for most natural results.

The copying machine is equipped with three turntables controlled by one switch, so that all are set in motion and topped simultaneously. There are three cutting arms, connected electrically with the pre-amplifier and sound filters. Only one turntable has a play-back and it is possible, by placing a disc record on this turntable with the play-back arm in place and cutter not in use, and by a proper combination of switches, to cut duplicates of this record as it is being played, on to blanks placed on the other two turntables.

The material selected as the recording medium for the discs is a specially annealed aluminum, for while this is acknowledged to be less desirable from most points of view than wax, celluloid or cellulose acetate, it has the two great advantages of being quite durable and very cheap. With properly designed cutting heads and properly annealed aluminum, the surface of which is also waxed or oiled for cutting, very fine records can be obtained. With wax blanks, which are acknowledged to be the best for absolutely faithful recording, it is necessary to make a galvanic metal master from the wax and then pressings in some plastic material, usually a shellac composition, from this master, a process which is not only involved, requiring expert laboratory technique and much additional equipment, but also very costly. Cellulose acetate and celluloid are also prohibitive, at present, but our machine has been constructed so that simple adjustments or replacements in the cutting features may be made which will take care of other media if these are economically developed in the future.

Three types of recording are in general use. The first employs pre-grooved discs and a relatively cheap apparatus which, however, gives inferior results, while the discs are expensive and of questionable wearing qualities. The second requires that a thread of the material be actually removed from the disc. This demands a sharp tool, and the material being cut must be relatively hard, which causes rapid wear of the cutting point, while both material and points must vary practically not at all. The results are apt to be less positive and the work requires much higher skill and attention on the part of the operator, while the permanence of the material does not equal that of the metal disc. However, the results are somewhat better, under ideal conditions, than those of aluminum discs, and steel needles

may be used in playing, which is an advantage. A third method creates a groove by embossing or pressing it into the material with a rounded point. This last is the simplest and the medium used for it is usually aluminum. The results are highly satisfactory, the main disadvantage being that in playing the records non-metallic needles, preferably of thorn or fiber, must be used, which wear very rapidly. The film of oil or wax placed on the blank before cutting has the double advantage of reducing friction and protecting the surface of the metal from corrosion, to some extent.

This is the method used on our machine. The early aluminum recording is not to be compared with the improved method resulting from the use of high quality equipment throughout, annealed aluminum discs, and the specially designed cutters now available.

The procedure of operation of the machine pictured is as follows: The cylinder is placed on the appropriate machine, which, if of spring-motor type, is kept wound up. The loud speaker switch and switch tuning in the proper cylinder machine are thrown on, and also the amplifier switch so that the amplifier may warm up, which requires about thirty seconds. The mandrel is started revolving and the pickup placed on the record, which may be played through while the operator experiments with the frequency and volume dials for proper effects. When these are learned, blank discs (one, two or three, as desired) are placed on the turntables and clamped down and carefully oiled. The quickest and easiest way to do this is to turn on the turntable switch, holding an oiled cloth to each revolving disc for even distribution of the oil. The turntable switch is then turned off, while the cutters are placed on the discs and the controls are set, the cylinder machine being started afresh. The turntable switch is again thrown on and the discs under the cutters allowed to revolve until they have gained maximum speed, when the pickup is placed on the cylinder. Controls may be altered while playing, but only in case of extreme need, as this changes the relative effect of parts of a recording. When the recording is finished the pickup or the cutter (either one) is lifted from the record or the disc while it is still revolving, after which the other is lifted and the various switches are turned off.

While it is hoped that all records collected from now on will be taken on better media than the wax cylinders and with apparatus incorporating the modern microphone and amplifier technique, these priceless earlier wax cylinders which represent irreplaceable and original scientific material should be re-recorded, not by the crude and unsatisfactory method of transferring to another cylinder, playing from

one machine into another by placing their horns together, nor by making casts of original cylinders, but by refined electrical technique. The day of the possibility of this achievement has now arrived, and the thousands of cylinder records of the vanishing and vanished music and languages of primitive and other folk may now in large measure be reclaimed and preserved.

[Helen H. Roberts and Lincoln Thompson]

Addenda

By a curious coincidence, as these instruments were being developed in America, similar instruments were independently devised and constructed in Germany by Walter Schur, for the laboratory of Professor Robert Lachmann. That is, a pick-up for transmitting sound electrically from cylinders to discs was perfected and a portable machine for electric recording on discs was built. The turntable of this latter machine is also driven by a spring so that the machine operates independently of public electric current. The high and low frequency cut-offs, however, vary considerably in construction from those in use on the Yale machines.

Apparently the German machines have been very satisfactory in the Archive of Oriental Music in the Hebrew University at Jerusalem from the first of the present year, — an archive which has recently been established under the direction of Professor Lachmann. It has as its chief aim the recording and studying of Oriental and Primitive music and that of the Near East, particularly Oriental Jewish music. It is proposed not only to record and study music at home and in the field, but to take care of the mechanical requirements in the machinery, the making and preparation of discs and duplicate copies. Up to now about fifty double-faced discs of Arab (urban 'villagers' and Bedouin) songs by both men and women singers have been secured, as well as Jewish and Samaritan songs, and this work will be extended in the coming year. The exchange of records with similar institutions is sought and information may be had by communicating with Professor Lachmann.

[Robert Lachmann]