

GUIDE to IDENTIFYING and DATING SOUND RECORDINGS

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The technology of sound recording has progressed through only four distinct stages during its 115 year history - the grooved cylinder, the grooved disc, magnetic tape, and the pitted disc.* There is, however, an astonishing variety of developments within each stage. For example, there were many ways that aural information was encoded in each stage (i.e. the grooves on cylinders or discs could be indented, cut away, pressed or molded and the grooves themselves could be formed vertically "hill and dale" or laterally "side to side"). Information has been encoded in both analog and digital modes. Some of these processes were commercially available and some were not. Some were standardized within the manufacturing industry, and some were the product of a single person or company. All of the processes overlapped chronologically with others. It may seem an overwhelming task to keep track of the various sound bearing contrivances.

Relatively accurate dating of sound recordings in archival, library, or museum collections can be accomplished, however, by placing these processes in a chronological context. The following list, while not all-inclusive, identifies most of the processes one may encounter in North America, as well as giving a name, dates, dimensions, materials and characteristics, and finally brand names and manufacturers where helpful.

* this paper is limited to sound-only recordings, not those recordings which incorporate sound and vision. Film soundtrack carriers such as the synchronized cylinder, disc and magnetic tape track, as well as the optical track, videotape and videodisc are excluded.

1877 - 1879 : *The Phonograph*

- first sound recording (that could be played back) invented by Thomas Edison
- given the name "phonograph"
- composition: brass cylinder covered with layer of tin foil into which grooves were indented with a stylus

- dimensions: 4 in. diameter, approximately 4 in. long
- playing time: 1 minute
- playing speed: variable as cylinder was rotated by hand crank
- note: unique item (no copies possible)
- very fragile: a cylinder could wear out after 6-10 playings
- manufactured by Edison Speaking Phonograph Co. in 1878 only

1885 - 1901 : *The Cylinder*

- wax cylinder introduced by Alexander Graham Bell/Chichester Bell/Charles Tainter
- given the names "graphophone" and later "phonocylinder"
- composition: sturdy cardboard tube covered with beeswax or carnuba wax compound into which grooves were cut
- vertical cut grooves 100 to the inch
- 3 sizes: 1) regular: 10.5 cm. (4-1/8 in.) long x 5.5 cm. (2-1/8 in.) diameter: 1889-1929
- 2) concert: 10.8 cm. (4-1/2 in.) long x 12.7 cm. (5 in.) diameter: 1899-1901
- 3) dictation: 15.5 cm. (6-1/8 in.) long x 6 cm. (2-3/8 in.) diameter
- playing time: 2 or 4 minutes
- playing speed: 160-200 r.p.m. (standardized for spring motorized or treadle playback equipment)
- packaging: usually packaged inside a slightly larger cardboard tube
- by 1889, cylinders were sold commercially making them the first pre-recorded sound carriers
- cylinders for home use could be shaved and re-used
- by 1896, duplicates could be made (25 copies to every master) by pantograph
- manufactured by American Graphophone Co., Columbia Phonograph Co., North American Phonograph Co. (until 1894), Edison National Phonograph Co.

- 2 colours: cream/white: 1885-1890; light brown: 1890-1901
- extremely fragile and subject to distortion by any heat (including body heat)

1887 - 1888 : *The Disc*

- flat disc patented by Emile Berliner
- given the name "Gramophone"
- composition: glass base coated with carbon powder, fixed with lacquer, and then etched with acid where grooves were cut
- lateral cut grooves
- 18 cm. (7 in.) diameter
- playing time: 1-1/2 minutes
- playing speed: varied according to speed used for cutting grooves
- note: unique items (no copies possible)
- extremely scratchy sound

1888 : *The Earliest Example*

- oldest known extant sound recording, a wax cylinder
- speech by Canadian Governor-General Lord Stanley at Toronto Industrial Exhibition on 11 September 1888

1888 - 1889 : *The Wax Disc*

- introduction of wax gramophone disc by E. Berliner
- composition: zinc base with bees wax coating into which grooves were cut, then etched with chromic acid
- 12.5 cm. (5 in.) diameter
- lateral cut grooves
- playing time: varied according to speed used for cutting grooves
- playing speed: variable as gramophone was hand cranked
- note: unique items (no copies possible)

1893 - 1897 : *Sturdier formats*

- introduction of hard rubber disc by E. Berliner
- composition: Vulcanite or Durinoid (a flexible shellac)

- first example of stamping from a reverse metal matrix, which itself was made from original acid-etched disc
- 12.5 cm. (5 in.) and 18 cm. (7 in.) diameters
- lateral cut grooves
- playing time: 2 minutes
- playing speed: variable as gramophone was hand-cranked (approximately 70 r.p.m.)
- relatively durable
- manufactured by United States Gramophone Co., Berliner Gramophone Co., Kammerer & Reinhardt (Germany)
- originally intended for children's toys

1897 - 1909 : *The Earliest 78s*

- 78 r.p.m. discs became industry standard as mechanized (spring-wound) turntables were standardized
- composition: shellac thermoplastic compound, grooves pressed from master stamper, wide variety of formulations
- could be mass produced
- 18 cm. (7 in.) diameter
- lateral cut grooves
- playing time: 2-1/2 minutes or 4-1/2 minutes
- playing speed: 78 r.p.m.(+/-5%)
- manufactured by Berliner, Columbia, Victor, Edison
- very durable, but become increasingly brittle with age

1899 - 1918 : *Wire recordings*

- first magnetic wire recording developed by Valdemar Poulsen
- given the name "telegrafon" or "telegraphone"
- composition: rolled carbon steel piano-wire on brass spoons or drums
- thickness: 0.010 in.
- playing time: varied with length of wire (full spool - 30 minutes)
- playing speed: 213 cm. (84 in.) per second (speed very high to compensate for lack of amplification)
- extremely fragile, susceptible to breaks
- unique item (no copies possible)
- used mainly as a dictation machine

1900 - present : *Labelling*

- introduction of pre-printed circular paper labels for commercial discs
- included at least recording company, artist, song title and serial number
- prior to this, information was pressed into disc with stamper

1901 - present : *The Double-sided Disc*

- introduction of double-sided discs (grooves on both sides) by Odeon Records and International Zonophone Co.
- given the name "double-disc"
- both vertical and lateral cut grooves
- idea originally patented by Colin McKenzie in Canada, J. E. Wassenich in U.S.A. and A. Petit in U.K.
- single sided discs continued to be manufactured until 1923

1901-1929 : *The Cylinder Era*

- introduction of molding process for mass production of cylinders by Edison Co.
- composition: celluloid (rigid cellulose nitrate with camphor)
- vertical cut grooves 200 to the inch (approximately half the thickness of wax cylinder grooves)
- playing time: 4 minutes
- playing speed: 180 r.p.m.
- colours: black, blue, purple
- maker's name and title molded on outer edge on one end
- packaging: usually packed in cardboard tube, in wooden tubes (turned on lathe), or in tins
- peak of popularity for cylinders was 1905 (Pathé ceased manufacture in 1906, Columbia in 1910, and Edison Bell in 1915)

1901 - 1956 : *The Ten-inch Disc*

- introduction of 25 cm. (10 in.) disc format
- originally known as "Red Leaf Records" or "Concert Records"
- composition: shellac thermoplastic
- lateral cut grooves
- playing time: 3 minutes
- playing speed: 78 r.p.m. (+-5%)

- 85-120 grooves per inch
- would become industry standard until manufacture discontinued in mid-1950's
- usually packaged in plain brown kraft paper sleeve with hole to show label
- after the long-play album was introduced, 78's were called "standard play"

1903 - 1956 : *The Twelve-inch Disc*

- introduction of 30 cm. (12 in.) disc format by the Gramophone Co.
- composition: shellac thermoplastic
- lateral cut grooves
- playing time: 4 minutes
- playing speed: 78 r.p.m.
- originally used for longer pieces of classical music
- format later adapted to LP album

1904-1908 : *The Plastic Disc*

- plastic disc named "Neophone"
- invented by William Michaelis of England
- composition: white celluloid (rigid cellulose nitrate) on a cardboard base
- 3 diameters: 23 cm. (9 in.); 30 cm. (12 in.); 51 cm. (20 in.) 1904-1906
- playing times: 4, 6, and 10 minutes (first long-play records)
- playing speed: 78 r.p.m. (+/-5%)
- not commercially successful as they had a very noisy surface, and were easily warped or broken

1906 - 1930 : *Grooves*

- introduction of discs with "run-out" grooves (centre to edge) by Pathé Company
- later given name "centre start disc"
- 11 in. diameter, double-sided
- there was much confusion in this period as discs with "run-in" grooves continued to be manufactured

1908 - 1912 : *The Amberol Cylinder*

- introduction of "Amberol" cylinder
- composition: thermoplastic called Condensite
- dimensions: 10 cm. (4 in.) long x 5 cm. (2 in.) diameter

- vertical cut grooves 200 lines to the inch
- playing time: 4 minutes
- playing speed: 160-180 r.p.m.
- mass produced and commercially available
- manufactured by Edison, and played on the Edison "Amberola"
- Columbia countered with a similar celluloid cylinder called the "Indestructable Cylinder"

1912 - 1929 : *The Blue Amberol*

- introduction of "Blue Amberol" cylinder
- composition: bright blue nitrocellulose plastic over top of plaster-of-paris core
- dimensions: 10 cm. (4 in.) long x 5 cm. (2 in.) diameter
- vertical cut grooves
- playing time: 4 minutes
- playing speed: 160-180 r.p.m.
- mass produced and commercially available, manufactured by Edison
- usually packaged in cardboard tube 11.5 cm. (4-3/4 in.) long x 6 cm. (2-1/4 in.) diameter
- not as brittle as the Amberol, and acoustically superior

1913 - 1929 : The "Diamond Disc"

- introduction of "Diamond Disc" by Edison Company
- double-sided disc
- composition: thermoplastic called Condensite into which grooves were pressed by master stamper
- 25 cm. (10 in.) diameter, 0.5 cm. (1/4 in.) thick
- vertical cut grooves
- weighed 1 lb. each
- playing time: 4 minutes
- playing speed: 80 r.p.m.
- could only be played on Edison or Pathé equipment, or with an adaptor mechanism and sapphire stylus

1930 - present : *Later Grooves*

- "Run-in" grooves (edge to centre) become industry standard
- discs with "run-out" still occasionally produced, but were rare

1930 - [1955] : *Magnetic tape (Anglo-American)*

- introduction of first magnetic tape in England by Louis Blattner, and the U.S. by Bell Telephone Laboratories
- playback equipment given name "Blattnerphone"
- composition: tungsten-steel ribbon, 6 mm. (1/4 in.) or 3 mm. (1/8 in.) wide, 0.08 mm. thick
- taken over by Marconi Wireless Co. in 1932 and slightly modified
- playing time: 1 reel 30 minutes
- playing speed: 1.5 metres per second
- used by CBC and BBC until early 1950s - equipment renamed "Marconi-Stille"
- very durable, but subject to rust

1933 - late 1960s : *Transcription discs*

- introduction of transcription discs, especially for broadcasting industry and recording studios
- given name "acetate" or "instantaneous recording" or "lacquer"
- perfected by Cecil Watts
- aluminum, copper or zinc base with coating of ethyl cellulose, cellulose acetate (with plasticizers) or nitrocellulose lacquer into which grooves are cut
- during WWII, the base was either glass or stiff cardboard since metals were needed for the war effort
- 5 diameters: 1) 40 cm. (16 in.); 2) 33 cm. (13 in.); 3) 30 cm. (12 in.); 4) 25 cm. (10 in.); 5) 18 cm. (7 in.)
- playing times: 16 in. (12 mins.); 13 in. (6 mins.); 12 in. (5-1/2 mins.); 10 in. (3-1/2 mins.); 7 in. (2-1/2 mins.)
- playing speeds: 33-1/3 r.p.m. or 78 r.p.m. depending on cutting speed and amount of information to be put on disc
- lateral cut grooves
- disc usually has 2 or 3 "drive holes" in centre label area (for securing disc to turntable during groove-cutting process - may be obscured by label)
- fragile, subject to wear each time a stylus is run through grooves. Not intended to be permanent
- plasticizers dry out or migrate over time. Results in more noise at best, and embrittlement, cracking and delamination at worst
- susceptible to fungus growth

- blanks manufactured by Audio Devices Inc., National Hollywood Recording Discs, Presto Recording Corp., Recordio Disc/Wilcox-Gay, Recoton Corp., Reeves Soundcraft

1934 - 1948 : *Magnetic Tape (Germany)*

- development of first magnetic tape in Germany by Dr. Gauss and BASF
- based on 1929 patent by Fritz Pfleumer
- composition: paper tape backing with carbonyl iron powder "varnish"
- 6.5 mm. (1/4 in.) wide
- playing time: usually on 35 cm. (14 in.) reels which lasted 1 hour
- playing speed: 77 cm. (30.3 in.) per second
- played back on equipment called "Magnetophon" by AEG Co.

1935 - 1970 : *Acetate Tapes*

- introduction of cellulose acetate plastic backing for magnetic tape by BASF
- original diacetate was quickly superseded by triacetate (CTA)
- given name "Cellite" or "C-Type" tape
- dark grey colour
- playing time: depends on length
- playing speed: 1 metre per second
- low tensile strength, will break before it stretches
- sensitive to humidity, becomes "wavy"
- prone to shrinkage, flaking

1936 - present : *Metal Tapes*

- introduction of ferric oxide coating for magnetic tape by 3M (Minnesota Mining & Mfg. Co.)
- Fe_2O_3 , or Fe_3O_4 , or $\text{Y-Fe}_2\text{O}_3$ (gamma ferric oxide)
- 2 colours: reddish-brown or black
- relatively insensitive to heat
- chemically stable, good for long-term storage

1943 - 1960 : *PVC Tape*

- introduction of polyvinyl chloride plastic backing for magnetic tape
- called "PVC" or "L-Type" tape

- very durable (more stable than binder layer)

1945 - 1955 : *Later Wire Recordings*

- introduction of magnetic wire recordings on a commercial basis (mainly North America)
- stainless steel wire magnetized on one side wound around a brass core or spool 7 cm. (2.75 in.) diameter
- .002 - .004 in. diameter
- playing speed: 51 cm. (20 in.) per second
- manufactured by General Electric, Brush Development Co., Armour Research, Webster
- fragile, easily broken
- could not be edited

1947 - present : *Tape Characteristics*

- introduction of magnetic tape to North America on a commercial basis by Ampex and 3M
- originally cellulose acetate base, then polyvinyl chloride, and finally polyester
- tape widths: 5 cm. (2 in.); 2.5 cm. (1 in.); 1.3 cm. (1/2 in.); .5 cm. (1/4 in.)
- tape thicknesses: .5, .75, 1.0, 1.5 mils
- reel sizes: 7.5 cm. (3 in.), 12.5 cm. (5 in.), 17.5 cm. (7 in.), 26.5 cm. (10-1/2 in.)
- playing speeds: 1) 4.8 cm. (1-7/8 in.) per second; 2) 9.5 cm. (3-3/4 in.) per second; 3) 19 cm. (7-1/2 in.) per second; 4) 38 cm. (15 in.) per second; 5) 76.2 cm. (30 in.) per second
- pre-recorded reel tapes made available to public in 1954
- by 1949 had replaced direct-to-disc recording as it was cheaper, could run for longer periods of time than a disc, and could be edited and enhanced before mastering
- manufactured by Ampex, Audio Devices ("Audiotape"), BASF, Bel Cleer Products, Brush Development Co. ("Soundmirror"), Burgess, Crescendo, Dr. Anderson's Hi-Fi, E.M.I., Ferrodynamics Corp., Jana, Kramer Magnetics Ltd. ("Pan Canada"), Maxell, MSS Recording Co. ("Mastertape"), ORRadio Industries Inc. ("Irish"), Radio Shack ("Realistic", "Supertape"), R.C.A., Reeves Soundcraft Corp., Robins, Sears ("Silvertone"), Shamrock, Sony, 3M ("Scotch"), Trubilt

1948 - present : *The Long Play Disc*

- introduction of long play album disc by Columbia
- given name "Microgroove" or "LP"
- 2 sizes: 1) 25 cm. (10 in.) discontinued in 1960; 2) 30 cm. (12 in.) became industry standard
- playing time: 25 minutes per side
- playing speed: 33-1/3 r.p.m.
- 250-350 grooves per inch (lateral cut)
- made of polyvinyl chloride with carbon black pigment (other colours and translucent LPs also produced) a.k.a. "Vinylite" which was developed by Union Carbide
- packaged in cardboard sleeve 31 cm. (12-1/2 in.) square
- degrades when exposed to UV light or heat
- susceptible to thermal cycling (seasonal changes): each cycle results in small deformations which are accumulative, and visible after as few as 5 cycles
- RCA had experimented with 33-1/3 r.p.m. LP (non-microgroove) in 1931, but it was short-lived

1949 - present : *The Single*

- introduction of "single" disc by R.C.A.
- composition: originally polyvinyl chloride, but in 1953 changed to more durable injection-molded polystyrene
- 17.5 cm. (7 in.) diameter
- lateral cut grooves
- playing time: 3 minutes per side: a variation on the single, the "EP" (Extended play) could play up to 7 minutes per side
- playing speed 45 r.p.m.
- 250-350 grooves per inch
- usually packaged in paper sleeve 18 cm. (7-1/4 in.) square with holes to show label

1955 - 1960 : *Polyester Tapes*

- introduction of polyethylene terephthalate backing for magnetic tape by Dupont Co.
- given name "polyester" or "PET"
- very thin but very strong
- unlikely to break, but could be stretched which resulted in irreversibly distorted signal
- great durability and longevity (more stable than binder layer)

- brand names "Mylar", "Estar", "Celanar"

1955 - present : *Stereophonic Tapes*

- introduction of stereo recording for magnetic tape by E.M.I. in U.K. and Ampex in U.S.
- use of 2-track recorder
- 2 channels of audio information

1958 - present : *Stereophonic Discs*

- introduction of stereo recording for LP format by Audio Fidelity Inc., Decca, and Columbia
- had been pioneered by Westrex Co. in 1957
- two channels of audio information in single groove
- given names "Duophonic" (Capitol), "Living Stereo" (RCA), "360° Sound" (Columbia), and "High Fidelity"
- monaural recordings still produced until [1970]

1960 - present : *Improved Polyester Tape*

- introduction of pre-stretched polyethylene terephthalate backing for magnetic tape by Dupont Co.
- thickness 1.5 mil.
- became industry standard by 1970
- did not stretch as easily as ordinary polyester (more stable than binder layer)
- unaffected by humidity
- very stable, even under adverse storage conditions

1963 - present : *Cassettes*

- introduction of compact cassette magnetic tape by Phillips
- composition: polyester base (.5 or .3 mils. thickness) with coatings of ferric oxide, chromium dioxide or metal particles
- tape: 3.8 mm. (1/8 in.) wide
- cassette casing: 10 cm. (4 in.) x 6.5 cm. (2-1/2 in.) x 1 cm. (3/8 in.) wide
- packaged in hinged plastic case 11 cm. (4-1/4 in.) x 6.5 cm. (2-3/4 in.) x 1.5 cm. (5/8 in.) wide

- standard playing times: 30, 60, 90, 120 minutes (15, 30, 45, 60 minutes per side), variations available
- playing speed: 4.76 cm. (1-7/8 in.) per second
- first pre-recorded cassettes commercially available in 1965
- "knock-out" holes on top edge a feature to prevent re-recording over a tape one wants to save
- manufactured by Ampex, BASF, Denon, Fuji, Irish, Laser, Maxell, Memorex, Phillips, Radio Shack, Robins, Sony, TDK, TEAC, Tempus, 3M ("Scotch"), Videosonic

1965 - [1982] : *8-Tracks*

- introduction of 8-track cartridge magnetic tape by Bill Lear
- evolved from the enclosed loop cartridge of George Eash (1954)
- tape: 1 cm. (1/4 in.) wide
- endless loop format on single reel within cartridge
- cartridge: 9.5 cm. (4 in.) x 13 cm. (5-1/8 in.) x 2 cm. (3/4 in.) wide
- packaged in cardboard sleeve
- playing time: 4 programs of 12 minutes each, for a total 48 minutes
- playing speed: 9.5 cm. (3-3/4 in.) per second
- impractical for home recording, so most 8-track tapes are pre-recorded commercially
- can be fast-forwarded, but not reversed

1967 - present : *Chrome Tape*

- introduction of chromium dioxide coating for magnetic tape by Dupont
- given description "low noise/high output" tape
- CrO₂ (higher particle density than ferric oxide)
- silver-black colour
- higher quality recording, became industry standard by 1976
- mainly used in compact cassettes
- sensitive to heat - may start distorting or losing information above 50° C
- particles may also change chemically and magnetically with prolonged exposure to high humidity

1972 to [1976] : *Quad*

- introduction of quadraphonic recording
- for LP disc and 8-track tape formats
- 4 channels of audio information
- given names "SQ" (Columbia), "Quadradisc" (RCA) and "CD-4" (Compatible Discreet 4-Channel)
- not commercially successful

1971 to [1972] : *"Dynaflex" LPs*

- introduction of "Dynaflex" disc by R.C.A. - for LP format
- extremely flexible - "unbreakable"

[1975] to [1982] : *Picture Discs*

- accelerated marketing of picture discs by musical performers
- LP and 45 r.p.m. format
- lateral cut grooves
- LP's packaged in cardboard sleeve 31 cm. (12-1/2 in.) with 12-inch hole to show whole disc, 45's packaged in clear plastic (polyvinyl chloride) pouch 18 cm. (7-1/4 in.) square
- first known picture disc precursor dates from 1905, made of transparent celluloid overlaid on lithographed illustrations
- RCA-Victor produced series of picture discs in 1933, Famous Records produced discs in 1939, and Vogue Picture Records produced discs 1946-47

1978 - present : *MP Tapes*

- introduction of "metal particle" (MP) coating for magnetic tape by 3M
- mainly used in compact cassettes
- composition: metal alloy 70% iron and 30% Cobalt, no oxide couplings
- significantly improved frequency response

1982 - present : *Compact Discs*

- introduction of compact disc jointly by Phillips and Sony
- perfected in 1978 but not commercially available (not manufactured in North America until 1984)

- composition: polycarbonate base with aluminum and acrylic lacquer coatings
- 12 cm. (4.7 in.) diameter x 1.2 mm. thick
- playing time: 72 minutes
- playing speed: 215-500 r.p.m. (continuously variable as disc is read from centre to edge)
- data bit rate 2.0338 megabits per second
- audio information on one side of disc only
- digital recording: information encoded as microscopic pits is read by laser light beam pickup
- packaged in hinged "jewel case", plastic, 14 cm. (5-1/2 in.) x 12.5 cm. (5 in.) x 1 cm. (3/8 in.)
- note: recordable CD's (CD-R) have been developed which encode information in reflective "phase-change" materials (antimony, selenium), and recordable/erasable CD's (MOD) have been developed using dye-polymers. Neither is commercially available and neither is compatible with available CD playback units
- low noise, low distortion, total absence of wow and flutter

1982 - present : *Microcassettes*

- polyester base with coating of ferric oxide or chromium dioxide
- tape: 3 mm. (5/16 in.) wide
- cassette casing: 5 cm. (2 in.) x 3.2 cm. (1-1/2 in.) x 0.7 cm. (3/8 in.) thick
- packaged in hinged plastic case - 5.5 cm. (2-1/4 in.) x 3.8 cm. (1-1/2 in.) x 1 cm. (7/16 in.) thick
- playing speeds: 1) 2.4 cm. (1 in.) per second; 2) 1.2 cm. (1/3 in.) per second
- playing times: 60 (MC-60) and 120 (MC-120) minutes, 30 and 60 minutes per side respectively
- used chiefly for telephone answering and dictation machines
- manufactured by General Electric, Memorex, Panasonic, Sony

1990 - present : *Digital Audio Tape*

- introduction of R-DAT (rotary digital audio-tape) to North America by Sony
- available in Japan since 1986
- composition: magnetic metal particle tape coating, polyester base
- tape: 4 mm. (1/8 in.) wide, 0.5 mil. thickness

- cassette casing: 7.25 cm. (2-3/4 in.) x 5.5 cm. (2-1/8 in.) x 1 cm. (1/2 in.)
- packaged in hinged plastic case: 8 cm. (3-1/8 in.) x 6 cm. (2-1/4 in.) x 1.5 cm. (5/8 in.)
- standard playing times: 60 and 120 minutes, variations available
- playing speed: 8.15 mm. per second
- digital recording
- data bit rate: 2.46 megabits per second

1991 - present : *"CD Single"*

- introduction of small format compact disc to North America by Sony
- given name "CD-single"
- composition: polycarbonate base with aluminum and acrylic lacquer coatings
- 8 cm. (3-1/8 in.) diameter
- playing time: 20 minutes
- playing speed: 215-500 r.p.m. (continuously variable as disc is read from centre to edge)
- compressed audio information on one side of disc only
- digital recording: information encoded as microscopic pits is read by laser light beam pickup
- packaged in cardboard sleeve 8.2 cm. (3-1/4 in.) square

1992 - present : *Digital Compact Cassette*

- introduction of "DCC" by Phillips
- composition: polyester base with chromium dioxide (video) coating
- tape: 3.8 mm. (1/8 in.) wide
- cassette casing: 10 cm. (4 in.) x 6.5 cm. (2-1/2 in.) x 1 cm. (3/8 in.) wide with sliding metal protective covering
- auto-reverse, cassette cannot be turned over
- packaged in hinged plastic case 11 cm. (4-1/4 in.) x 6.5 cm. (2-3/4 in.) x 1.5 cm. (5/8 in.) wide
- compressed audio information in 8 channels
- playing times: 90 minutes (D90), 120 minutes (D120), 45 and 60 minutes per side respectively
- playing speed: 4.76 cm. (1-7/8 in.) per second

- low noise, low distortion, total absence of wow and flutter
- DCC player will play back both analog and digital cassette tapes

1992 - present : *Miniature Compact Disc*

- introduction as "Mini disc" by Sony
- composition: polycarbonate base with aluminum and acrylic lacquer coatings
- 6.3 cm. (2.5 in.) diameter
- playing time: 60 minutes (MDW-60) and 74 minutes (MDW-77)
- playing speed: 215-500 r.p.m. (continuously variable as disc is read from centre to edge)
- data bit rate 1.4 megabits per second
- compressed audio information on one side of disc only
- digital recording: information encoded as microscopic pits is read by laser light beam pickup
- packaged in protective plastic "caddy" 7 cm. (2.75 in.) square
- note: contains a "shockproof" semiconductor memory chip which eliminates skips or mistracking
- recordable mini-CDs have been developed using magneto-optical (MO) technology where the recording layer encodes information as minute changes in polarization
- low noise, low distortion, total absence of wow and flutter

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