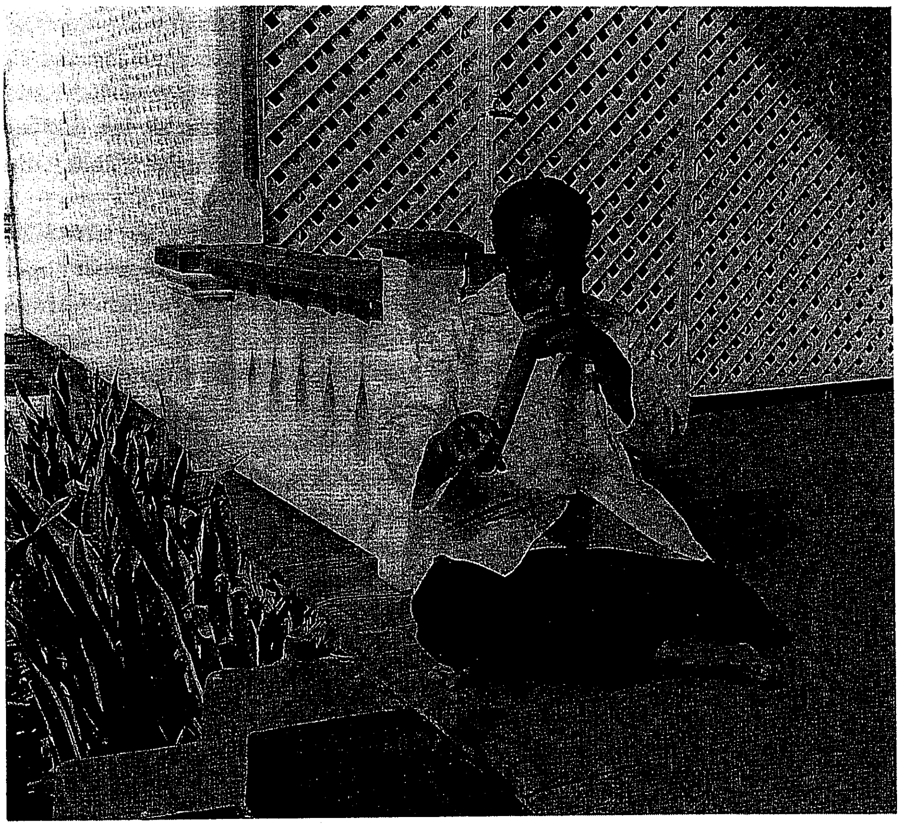
FIGURE 1 (*continued*)

TRACK 19



(*d*)

differences between insiders' and outsiders' outlooks, and suggests the importance of respecting the classificatory thinking of the people to whom instruments are culturally meaningful. —J. W. LOVE

IDIOPHONES

Objects that by virtue of their shape and the materials from which they are constructed make musically useful sounds when mechanically excited are classified as idiophones, meaning that they sound "of themselves." Mechanical excitation usually involves hitting the object with some sort of hammer (as with log idiophones, wooden plaques, and xylophones), or hitting one part of the object against another (as with clapsticks, paired stones, and castanets). The first case is percussion; the second, concussion. In each case, the vibrating object radiates its sound directly, though some idiophones (hollowed log idiophones, castanets) have an air-cavity resonator. Other methods of excitation include hitting the object against the ground or water (figure 2), or against a person's hand or body (the Hawaiian stick rattle, *pū'ili*).

A struck object vibrates in sonic patterns called normal modes, each of which has a characteristic form, determined by the shape of the object, and a characteristic frequency, determined by the size, shape, density, and elasticity of the material. The shapes of some idiophones make one mode acoustically dominant. Known as the fundamental, this mode is usually that of the lowest frequency. It gives a definite pitch. More precisely tuned idiophones, such as the slats of xylophones, bring the next higher mode (the first overtone) into harmonic relation with the fundamental, enhancing the sensation of pitch. Tuned idiophones may be played as sets, allowing the production of melodic motifs.

The sounds of Oceanic idiophones are transient. The time each sound persists depends on the material from which the instrument is made. A prolonged sound requires a large mass of heavy material, such as metal, with small internal losses of energy. Indigenous Oceanic societies did not forge metal, so their idiophones are typically of wood, whose sound dies away more quickly because its lower density stores less energy and has higher internal losses. Metal idiophones used in Irian Jaya are imported from Indonesian islands farther west.

FIGURE 2 An idiophone rhythmically plunged into water to produce sounds said to be the voice of an ancestral crocodile. East Sepik Province, Papua New Guinea. Photo by Museum der Kulturen Basel.

Log idiophones

Socially and musically, the most important indigenous Oceanic idiophone may be the log idiophone, a percussion instrument hewn and hollowed from a solid piece of wood. Log idiophones are played in part of northeastern New Guinea, much of Melanesia and West Polynesia, and parts of East Polynesia. Log idiophones take many sizes and shapes. Ensembles of differently sized instruments are notable in central East Polynesia (Cook Islands, Society Islands) and Melanesia. Most versions in western Oceania have a slit narrower than the width of the cavity; Polynesian versions usually have a slit about as wide as the cavity. Most Oceanic log idiophones lie horizontal, but peoples of central Vanuatu set them upright in the ground.

The enclosed air plays a large part in defining the sound and pitch of a log idiophone, since the cavity and slit together form a Helmholtz resonator, excited by vibration of its walls under the influence of a sharp knock. The larger the cavity and the narrower the slit, the lower the pitch. Stamped bamboo tubes, closed by a node below and open above, work similarly, but the air takes the form of a long cylinder.

Players obtain sounds from log idiophones by either of two actions: striking and jolting (see below). Striking gives a short time of contact because the stick rebounds, and the stroke is light because it is determined mostly by the weight of the stick. Jolting gives a heavy stroke and a long time of contact because the weight of the player's hand and arm is effectively attached to that of the stick, and must move with it.

Other idiophones

Indirectly struck idiophones often fuse dance and music by turning human movements into sounds. Held, or tied to a human torso or limbs, they use a dancer's energy to excite the vibration of various objects: natural bells, made from snail shells, and especially in western Oceania the fruits of *Pangium edule;* chain rattles, in which resonating bodies fastened in series to a string hang from a belt circling the dancer's waist, arms, or legs (figure 3); and bundle rattles and frame rattles, in which resonating bodies fastened to a string cluster in bundles, inside a frame, or on a stick, usually held in a hand. Other Oceanic rattles include suspension rattles, like shark-catching rattles, in which coconut-shell halves are threaded onto rattan rings or sticks, and the *ʻūlili,* a Hawaiian pulled rattle, with three empty gourds attached to a string; vessel rattles, usually a gourd containing pebbles, as in the Hawaiian *ʻulīʻulī;* and stick rattles, in which the end of a stick is split so individual lengths vibrate against each other, as in the Hawaiian *pūʻili.*

TRACK 20 Some idiophones are sounded by plucking. The lamellaphone has a flexible tongue, set or cut within a frame and twanged by a finger or knocked by an attached cord. A quiet instrument, it can produce multiple timbral effects, determined by the size and shape of the player's oral cavity and vocal tract, which act as a resonator. Lamellaphones can convey the illusion of speech, and they may have social value as means of communication among friends and lovers. Especially in Melanesia and New Guinea, they serve as agents of love-controlling magic. In keeping with this symbolism, several western Oceanic societies liken the rhythmic twanging of a lamellaphone to the sexual action of a penis.

Rarely, the vibrations of Oceanic idiophones—notably, an instrument of New Ireland (see below)—are excited by friction. Depending on the materials involved, an

FIGURE 3 A Hawaiian dancer wears chain rattles (*kūpeʻe nihoʻīlio*) tied under his knees, and in his hand shakes a feather-decorated vessel rattle (*ʻulīʻulī*). Drawing by John Webber during Cook's third voyage, 1778. Photo by Smithsonian Institution.

appropriate degree of friction between the rubbing hand and the surface of the idiophone is achieved by the application of moisture or resin. The vibrations excited often have a high pitch because they are predominantly parallel to the surface rubbed, and the rubbing tends to excite a single mode, giving a definite pitch.

—J. W. LOVE, NEVILLE H. FLETCHER

Hollowed log idiophones of Papua New Guinea

The hollowed log idiophone (Tok Pisin *garamut*) is one of the largest instruments in Papua New Guinea. Garamuts are frequently made of *Vitex cofassus,* a tree also called garamut. The inside of the instrument is hollowed out through a 10-to-15-centimeter-wide slit, running its length. Carved representations of spirits or other images may adorn one or both ends of the log. Most garamuts are between two and three meters long, but some are more than four meters long.

On the New Guinean mainland, garamuts are used in an area that extends from just west of the border with Indonesia (near Jayapura), eastward along the coast and up major rivers, to the vicinity of Lae. It is used throughout the insular provinces, but is absent from Wuvulu-Aua (Manus) and the Baining area of East New Britain. This distribution and that of cognate terms for the instrument suggest that garamuts may have arrived with secondary settlers, long after initial settlements.

Garamuts are played with sticks, whose number and manner of use differ. Instruments are *jolted* if the garamut is hit with the end of a stick (figure 4); they are *struck* if hit with the side of a stick (figure 1*a*). Jolted garamuts are usually hit with a single stick; in the Middle Sepik area, they are hit with two short sticks, one in each hand. In Manus Province, most garamuts played in ensemble are struck with two sticks.

An isolated example of a garamut-like idiophone appears in the Yonggom area of Western Province, where the instrument is shaped like an oblong bowl with a wide mouth, and is struck on the inside with a stone. Another major deviation from the general form of the garamut occurs at the westernmost limit of its distribution: at Wutung, near the Indonesian border, players strike a suspended plank.

FIGURE 4 Men of Balil Village, Nissan Island, jolt hollowed log idiophones with bundled sticks. Photo by Steven R. Nachman, 1971.

noise. This pattern is unusual among idiophones. In culturally conditioned noninitiates, the sound of twenty or more of these instruments being played at once may indeed arouse fear.
—GERALD FLORIAN MESSNER

MEMBRANOPHONES

Instruments of the drum family—membranophones—have as their vibrating element a thin membrane stretched elastically over a supporting rim. The membrane controls the vibrations and is responsible for efficiently radiating the sound. The frequencies of the vibrations are set primarily by the thickness of the membrane, the tension with which it is stretched, and its area. A thin membrane of small area under high tension produces a high fundamental pitch. The shape of the membrane has a less important effect on frequency.

The membranes of drums are usually supported on deep cylindrical rims, partly for convenience and mechanical strength, and partly to separate acoustically the two sides of the membrane, increasing the loudness of the radiated sound. The rim of some drums extends to form a nearly closed cavity or a long pipe, and the elastic properties of the air in this cavity can modify the vibrational frequencies of the membrane. The general effect of such a cavity is to act as a resonator, reinforcing the radiation from particular low modes of the membrane's vibration, giving the drum a distinct pitch.

Changing the tension of the membrane can vary its pitch over a moderate interval, typically about a major third up or down. The frequency can be lowered by the attachment of a heavy object or objects to the center of the membrane. This attachment has the effect of making the first few membrane-generated frequencies nearly harmonics of its fundamental, giving the drum a pronounced tonal character. Such a technique is common on kundus, hourglass-shaped drums of New Guinea, to whose membranes players often affix pellets of wax or resin. Vigorous strokes increase the tension of the membrane, so that its pitch, at first slightly high, falls as the sound decays; this effect may be more noticeable with a loaded membrane.

The indigenous drums of Oceania have only one membrane, typically the skin of a lizard in New Guinea and Melanesia, and of a shark in Micronesia and Polynesia. Western Oceanic drums are normally tubular or hourglass-shaped instruments held in the hand; most Polynesian drums are free-standing, footed kettledrums. Kundus and East Polynesian kettledrums often bear intricate carvings: kundus on the handle and the body; kettledrums on the feet and supporting stand, often depicting stylized human shapes holding up the rest of the instrument.

Oceanic drums are typically played with the fingers and the palms. The palm, which remains in contact with the membrane, gives a heavier sound, but strokes of fingers or sticks give lighter and more ringing tones. The Tahitian *pahu* and the Tongan *nafa,* huge double-headed drums played with a stick or sticks, derive from European bass drums (figure 8). The Hawaiian *pūniu,* a fishskin-headed coconut shell often tied to a dancer's knee, is played with a braided fiber thong [see MUSIC AND RELIGION, figure 9].

Snare drums, introduced for use in brass bands and pipers' bands, have two membranes, usually at opposite ends of a cylindrical shell. With sticks, the player strikes the upper membrane. The acoustic effect of the lower membrane can be varied by tuning it in unison with the first or to some other interval. The lower membrane has cords (snares) running just above its surface, so its vibration causes impact with the snares and generates a high-frequency rattle, emphasizing rapid rhythms.

The sound of a drum decays rapidly because the membrane, being light, cannot store much mechanical energy, and being large in relation to its thickness, loses its energy quickly by radiating its sound. Sounds produced by drums with snares decay

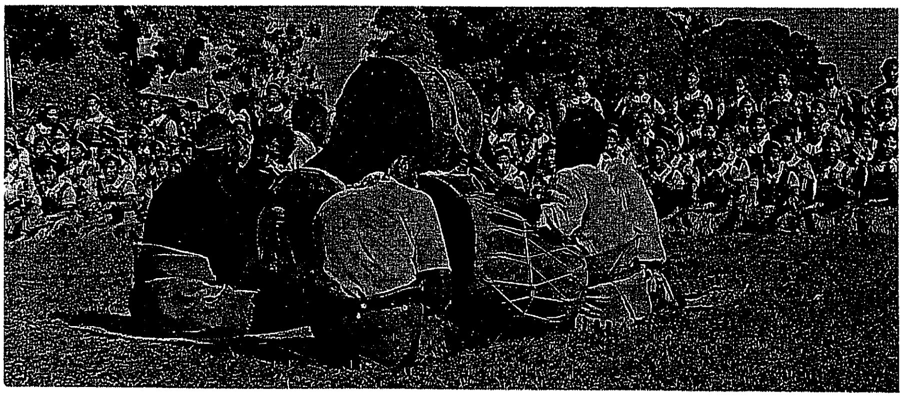


FIGURE 8 At the Methodist conference of 1967, Tongan men play three *nafa.* Photo by Adrienne L. Kaeppler.

rapidly, but sounds produced by drums with a large coupled-air volume have longer times of decay. These traits affect how various membranophones function: in Oceanic brass-band music, bass drums normally accent downbeats; snare drums, though they often reinforce downbeats, add decoration on offbeats.

The timbre of a drum can vary in two ways. First, striking the drumhead in different places can excite its vibration modes to different relative amplitudes. Because a fundamental excited by a central blow is rapidly damped, drummers usually strike the head near one edge, so as to make the next higher mode the prevailing one in the excitation. Second, changing the hardness of the beater can vary the timbre: a small, hard beater excites all modes of the membrane, giving a sound describable as hard and dry; a large, soft beater damps out higher-frequency modes, concentrating vibrations into modes of lower frequency and giving a deeper sound.

—J. W. LOVE, NEVILLE H. FLETCHER

Kundus of Papua New Guinea

The drum known in Tok Pisin as kundu (Hiri Motu *gaba*) is one of the most widespread instruments of Papua New Guinea. It is so important that it adorns the national emblem [see THE MUSIC AND DANCE OF MELANESIA: figure 1]. It is found in every province of the country, but in parts of the Island Region it is absent, especially in much of Manus, the eastern part of New Ireland, the Baining area of East New Britain, and most of North Solomons.

Most commonly, the body of the kundu is shaped like an hourglass; cylindrical, conical, and goblet shapes also occur. A typical length is about 80 to 90 centimeters, but in some areas, instruments are small (about 27 centimeters) and long (about 280 centimeters). The wood used for kundus varies by local preference and availability. The most common species are *Pterocarpus indicus* (Tok Pisin *nar*), *Vitex cofassus* (*garamut*), *Intsia bijuga* (*kwila*), and trees of genus *Litsea.*

The wood is hollowed out by a combination of scraping, chiseling, and burning. The people of some areas carve a central handle from the wood. Designs may be carved into the body of the instrument and painted; the presence or absence of such decorations and their form are culturally specific. The open end of the instrument is usually left in its round shape, but in parts of Gulf and Western provinces it may be carved into jawlike forms. As a substitute for wood, bamboo sometimes serves. In the Adzera area of Morobe, the body of the *simpup gur* is made of clay—apparently the only such occurrence in the country.

Many kinds of skin serve for the drumhead. In lowlands, the skin of the monitor (*Varanus indicus*) is commonly used; in the highlands, where large lizards are absent, the skin of the ringtail (*Pseudocheirus forbesi*) is frequently used. Skins from other large lizards, crocodiles, sea snakes (especially *Acrochordus arafurae* in coastal areas of shell, provides an additional sound when a player strikes the skin with a braided fiber thong. A rich vocabulary—denoting the size and the shape of the drums, the musical parts various drums play, the sounds of the drums, the techniques used in drumming, and the social functions of the drumming—has cognate terms throughout East Polynesia.

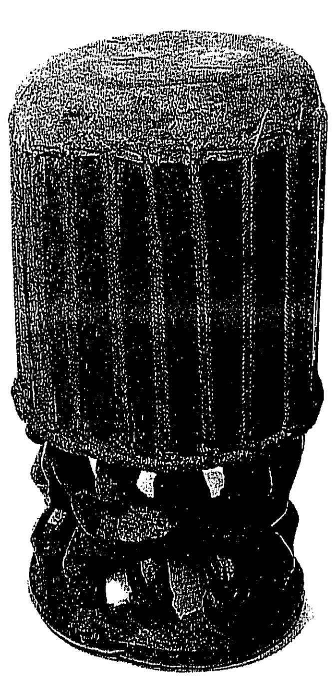


FIGURE 9 A Hawaiian *pahu* with human images, whose upstretched arms form crescents; collected during Cook's third voyage, 1778–1779. British Museum, London. Photo by British Museum.

TRACK 27

Performance using pahu

A performance can combine a text, the sounds through which it is articulated, a drum, the sound of the drum, the human movements through which the drum sounds, and associated ritual movements. *Pahu* may be played singly; or, for an array of different pitches and timbres, they can be played in pairs or sets of different sizes (Tatar 1993).

Early written references to *pahu* usually situate them in sacred ritual use in outdoor temples, played for the articulation of texts on one tone or a few tones usually described by outsiders as chanting, and often associated with ritual movements usually described by outsiders as dancing. The carving of the base often portrayed a series of upturned crescents (Hawaiian *hoaka*), which in the earliest surviving examples (from the late 1700s) appear to be abstracted symbolic representations of upstretched arms (figure 9). These crescents may have housed the drum's spiritual strength, its mana (Kaeppler 1993).

Pahu are sounded in rhythmic motifs that often bear names. In Hawai'i, typical motifs are played with *pahu* and *pūniu* in standard forms, though with varied stresses. As high-status ritual objects, *pahu* received personal names, and they were fabricated in association with rituals dealing with carving the body and lashing the membrane. The sound they produced was considered a voice, and they were inherited within chiefly or priestly lines. Besides being used in the service of gods, *pahu* announced important births, opened and closed wars, and marked funeral and memorial services. Today, they accompany dances and rituals of ethnic identity, especially in Hawai'i and Tahiti. —ADRIENNE L. KAEPPLER

CHORDOPHONES

Since the late 1800s, the inventory of chordophones in Oceania has probably undergone more drastic changes than have that of the other classes of instruments. As indigenous musical instruments, chordophones were rare; but in the form of guitars and ukuleles, they have become common, and their music has crossed cultural and national borders in ways other indigenous instruments have not.

The indigenous chordophones are quiet instruments. Their sound is usually audible only to their players and to listeners no more than a few meters away. Most cultures of Oceania highly value the noisiness of public display, correspondingly devaluing soloistic instrumental performance. Indigenous chordophones therefore do not enjoy public prestige. They are often instruments of private magic, lovers' communication, and children's amusement. Introduced chordophones—banjos, guitars, mandolins, ukuleles—are louder; when played in ensembles, and especially when amplified electrically, they accompany singing and dancing in public venues, and even furnish instrumental music without singing.

Stretched strings are musically important because their pitch can readily be changed. The fundamental frequency of a string varies directly as the square root of its tension and inversely with its length. To reach a given frequency, thick and heavy strings require greater tension than light strings. String tension is usually adjusted to fix the basic pitch of the full-length string, and stringed instruments can have strings of different lengths for different tones, as do multistringed idiochord tube zithers of

In the New Guinea islands, modern instrumental music and nomenclature show Polynesian influence. As a musical shorthand, this nomenclature enabled musicians to play together without rehearsal. Musical leaders could give verbal cues to guide performances.

FIGURE 10 Mabu plucks the string of a Huli musical bow. Photo by Jacqueline Pugh-Kitingan, 1978.

Irian Jaya (Van Hille 1907:621) and two-stringed musical bows of New Ireland and the Solomons (Kunst 1967:47). In New Britain and the Sepik area of New Guinea, a tuning noose enables one string to produce two tones (Fischer 1986:71).

Stopping, usually with a finger, can reduce the vibrating length of a string and raise its pitch. Halving the length of the string doubles the frequency, raising the pitch by an octave. Pitch may be varied in fixed steps (when a fingerboard has frets), or continuously (when a fingerboard is smooth). The former method is typical of introduced chordophones; the latter, of indigenous ones.

Exciting vibrations

A player may excite vibrations simply by plucking or striking a string (figure 10). The position of the pluck or strike affects the relative amplitudes of the overtones: high overtones have greater relative amplitude when the excitation point is near one end of the string. The amplitude of the vibration is proportional to the force of the pluck or strike.

Typical methods of playing chordophones in Oceania are plucking with a finger or a plectrum, and striking with a light stick. Each of these methods is used for musical bows of New Guinea, the Solomons, Vanuatu, and East Polynesia. An important Polynesian musical bow is the *ʻūkēkē*, a half-meter-long multistringed Hawaiian bow, held crosswise in the mouth, with unstopped strings plucked by the fingers or a plectrum. Similar bows, with cognate names, are used in the Marquesas, the Tuamotus, and the Society Islands; a comparable bow with a different name is used in Aotearoa.

The amplitudes of high overtones are reduced if the string is made of soft material, which dissipates high-frequency energy. Such is sometimes the case with idiochord instruments, whose string may be a fiber separated and raised up from the body of the instrument.

Strings can also be excited by the friction of a transversely moving bow, made from hair stretched on a wooden frame and treated with material such as resin to increase the friction. That is the usual method of sounding violins and related instruments, but it was rare or unknown in precontact Oceania.

Resonating vibrations

A simple vibrating string radiates almost no acoustic energy because its diameter is small relative to the wavelength of the sound. For this reason, at least one end of the string is usually connected to a larger structure, like a gourd or a wooden box, which the string sets into vibration, radiating the sound. The resonances of this structure selectively reinforce overtones of the string's vibration in particular frequency ranges, giving each instrument a characteristic timbre.

The musical quality of a stringed instrument depends on the acoustic properties of the resonant body. The connection between the string and this body is sometimes made by anchoring the end of the string to it, or (in the case of idiochord bows) raising fibers up from the bow. On instruments of the violin family, a light structure, called a bridge, is placed between the strings and the body. Plucked stringed instruments, like guitars and ukuleles, have one end of the strings usually attached to a light anchoring bridge mounted on a thin part of the body, the soundboard.

Musical quality can also depend on attachments to the resonator. The *belembaotuyan,* an introduced musical bow of the Marianas, exemplifies this use. A player cups the open side of the resonator against his belly. Its pressure against his skin, and the tautness of his abdominal muscles, affect the timbre of the resonated sound.

—J. W. LOVE, NEVILLE H. FLETCHER

Guitars in the New Guinea islands

Between 1945 and 1965, chordophone-based ensembles known first as *pilai gita* 'play guitar' (or simply *pilai*) and now as string bands (Tok Pisin *stringben*) emerged in Melanesia. Guitars and ukuleles, largely because of their portability and affordability, were the foundation of these ensembles. Melanesians especially liked the guitar's potential for stylistic versatility, since it was equally adaptable to styles performed in Allied camps during the war—swing, boogie-woogie, cowboy—and gospel and Hawaiian songs. Guitar proficiency became a desirable social skill (Attenborough 1960:164).

Tunings

In the New Guinea islands, modern instrumental music and its associated nomenclature show strong Polynesian influence. Fundamental to this music was the concept of tuning (Tok Pisin *ki* 'key'). The term *ki* originated with slack-key guitars (Kanahele 1979:353) in Hawai'i, where, as in the New Guinea islands, the word *ki* forms part of local names for specific slack-key tunings.

In the 1940s, New Guinea islanders learned a tuning known as *Fiji ki* 'Fijian tuning'. This may have been an alternative name for *faiv ki* 'five tuning' or *tri ki* 'three tuning', or for both terms, which, with *blu maunten* 'blue mountain' (also *blu ki*), New Guinea islanders favored in the 1950s. Tolai guitarists were familiar with tunings known as *Suva ki* 'Suva tuning', *Awai ki* 'Hawaiian tuning', *Taiti* 'Tahitian', and *Spenish* 'Spanish'; they believed, as did others (Lomax n.d.; Waterman 1990:46–47), that Spanish tuning had originated in Hawai'i. By the late 1950s, numerous guitar tunings were circulating in the New Guinea islands. Jack Tonga, an outstanding guitarist and songwriter from the Duke of York Islands, composed songs in at least ten tunings. Other performers, including the Tolai master John Wowono, specialized in only one or two tunings, developing idiosyncratic styles.

Around Rabaul, performers used the term *ki* in more general ways. *Rong ki* 'wrong tuning' designated the modification of a standard tuning, usually in the islands by lowering the pitch of one string. Most tunings had associated *rong ki*; some players used *rong ki bilong faiv ki* 'wrong tuning of five tuning'. The term *rap ki* 'rubbed tuning' distinguished tunings capable of being picked or strummed. Jack Tonga says the Hawaiian, Fijian, and Spanish tunings are all *rap ki.*

Stylistic elements in the New Guinea islands

The existence of a standardized pidgin nomenclature bespeaks a process of social cooperation involving the pooling of knowledge about pieces and practices. As a musical shorthand, this nomenclature enabled musicians to play together without rehearsal. Strong musical leaders could give spontaneous verbal cues to guide ensembles through performances.

The harmonic vocabulary of most songs in most tunings was limited to the primary triads: chords I, IV, and V, known as *wan, tu, tri,* respectively. A major chord built on the second scalar degree (functioning as V of V) was known as *flat.* The use of this chord signaled a fleeting modulation to the dominant key. Bands of the 1940s

AEROPHONES

Instruments in which air is excited into vibration are called aerophones. They include purely air-driven instruments (flutes, whistles) and those that have an air-driven valve, like a reed (oboes, clarinets, saxophones) or a player's lips (conchs, didjeridus, trumpets). The sound of most aerophones is largely controlled by the behavior of a column of enclosed air. This behavior is best understood in terms of the properties of ideally cylindrical or conical tubes, either open at the point of blowing, as with flutes, or effectively closed, as with reed-driven or lip-driven instruments. The deflecting jet, vibrating reed, or buzzing lips are controlled in part by the vibrations of the column of air, but the physical mechanism is different for each of these classes.

Any enclosed column of air has characteristic vibrational modes, in which pressure waves propagate from one end to the other. No sound escapes directly from a closed end, and surprisingly little escapes from an open end, most of the wave being reflected back inside the tube. For a flute open at or near both ends, the possible vibrations of the enclosed air are those for which the length of the tube is an exact number of half waves, leading to a complete harmonic series with frequencies f, $2f$, $3f$, and so on.

For a cylindrical flute closed at the remote end, or for a cylindrical reed-blown or lip-blown tube open at the remote end and effectively closed at the blowing end, the possible vibrations of the air are those with an odd number of quarter waves in the tube, giving only the odd harmonics f, $3f$, $5f$, and so on. Because the fundamental f corresponds to a quarter wave in this case, it is an octave below the frequency of a doubly open pipe of the same length. A complete conical tube blown with reed or lips at the small end has the same resonance frequencies as a doubly open cylindrical tube of the same length. Lip-driven instruments with flaring tubes have resonance properties intermediate between those of cones and cylinders, usually producing a series about like $0.8f$, $2f$, $3f$, and so on.

On some aerophones, a skilled player can produce all the modes of the air column separately, giving bugle-call capabilities by varying the blowing pressure, the tension of the lips, and the volume of the mouth. Many aerophones have facilities for changing the effective length of the air column to fill in intermediate notes. The player may shorten the column by successively opening holes along its length (as with oboes, clarinets, and most Oceanic flutes) or inserting a stick into the open end (as with piston flutes), or may lengthen it by adding cylindrical tubing engaged by a slide (as with trombones) or a series of valves (as with trumpets, valved horns, and tubas).

TRACK 24 The swung slat, common in New Guinea, Melanesia, and Aboriginal Australia, occurs only sporadically elsewhere in Oceania. An extremely simple aerophone, it does not have any column of air or associated cavity. It is usually a thin, lens- or rhomboid-shaped wooden slat, attached to a string and swung through the air. Its fundamental pitch is determined by the aerodynamic forces of lift and drag on the rotating slat, and hence by the size and shape of the wood, the length of the string, and the speed of the player's swing. It often has a sacred significance, and how a player makes it hum is kept secret from uninitiated persons.

Oceanic end-blown flutes include piston flutes, water flutes (which work similarly, but consist of an open-ended tube set into water), and flutes with holes for fingering. Most are made of bamboo. The commonest in Vanuatu and the Island Region of Papua New Guinea is a notched flute; the player blows against a notch at one end. In side-blown flutes, the player blows into a hole near one end of the tube. Side-blown flutes with one end closed occur in several areas, but are typical of New Guinea. A few side-blown flutes have both ends closed.

In the flutes discussed above, the player sets the air column in motion by exhaling through the mouth. A typical Polynesian flute is a nose-blown instrument [figure 1*d*, and see THE MUSIC AND DANCE OF POLYNESIA, figure 1]. Having closed one nostril with a finger or a thumb, the player exhales through the other nostril into the instrument. West Polynesian flutes include side-blown instruments closed at both ends. The hole for blowing is the same size as the holes for fingering, which often lie symmetrically and equidistantly from each other, so the flute can be blown from near either end.

An elaboration of flutes occurred in Aotearoa, which developed a three-holed end-blown flute open at both ends and having three holes with two close to each other (*kōauau*), a similar flute with three equidistant holes in the middle (also *kōauau*), a similar flute with three holes close to one end (*porutu, whio*), a side-blown flute with a hole for blowing near the closed end and three holes for fingering near the open one (*rehu*), a short nose-blown flute open at both ends (*nguru*), and a tapering tube usually open at both ends and with one hole in the middle (*pūtōrino*) (Fischer 1986:107).

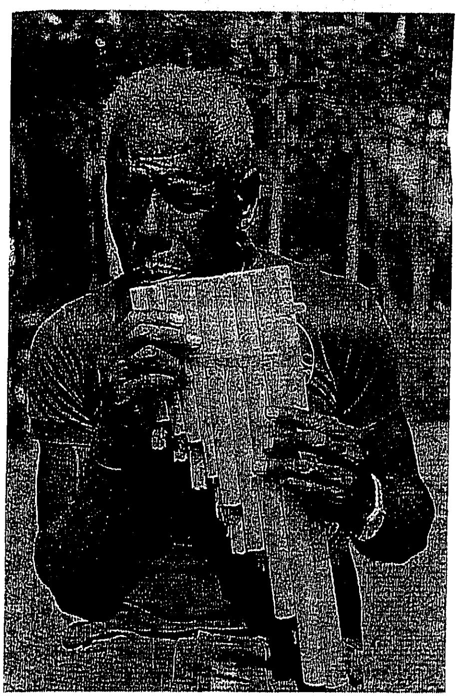
Some Oceanic societies formerly used aeolian flutes, instruments whose sound is produced by the action of wind. These flutes were usually tall bamboo poles set up on the beach, where sea breezes made them give out variable sighs and moans, thought to represent the voices of ancestors or spirits.

Another important Oceanic instrument is the panpipe, a set of end-blown flutes (figure 12). *Raft panpipes* have tubes bound in a row; *bundle panpipes* have tubes bunched together. The former are more widely used, and often play in ensembles of instruments in several sizes, whose fundamental tones cover a range of several octaves. From observing the acoustical results of blowing into measured lengths of bamboo tubes, the ʻAreʻare of the Solomon Islands have verbalized a theory of musical tonality (Zemp 1979).

Other kinds of Oceanic flutes are vessel flutes, whose body is neither cylindrical nor conical, including the Hawaiian *ipu hōkiokio,* a nose-blown gourd with three holes for fingering. In these instruments, the body acts as a Helmholtz resonator, and only the sizes, not the positions, of the holes have acoustical importance. Other Oceanic vessel flutes are whirring nuts and other swung vessels, and humming tops.

End-blown wooden trumpets are especially common in New Guinea. A special case is the didjeridu of Aboriginal Australians (see below). Another important lip-driven aerophone, the most widely used indigenous Oceanic musical instrument, is the conch trumpet, made from shells of marine gastropod mollusks of genera *Triton* (less commonly the similar genera *Fusus* and *Strombus*) and *Cassis.* Internally, each shell is a short conical spiral. Penetrating the point of any of these shells results in an end-blown instrument; all but *Cassis* can be blown from a hole made in the side. Conchs usually serve as instruments of signaling. Each instrument produces just one tone, and overblowing to the difficult second mode is not employed. After the introduction of European four-part tonal harmony, the sound of these instruments led to the invention of unique ensembles, the conch bands of New Guinea [see POPULAR MUSIC: Bands].

—J. W. LOVE, NEVILLE H. FLETCHER



(*a*)

(*b*)

FIGURE 12 Two kinds of panpipe: *a,* a man of the Shortland Islands plays a double raft panpipe (photo 1991, courtesy of the MABO Project); *b,* Ibidali plays a common Huli bundle panpipe, *gúlupòbe* (photo by Jacqueline Pugh-Kitingan, 1978).

Didjeridus of Australia

The didjeridu, a wooden trumpet about 1 to 1.5 meters long, is played by Aborigines of northern Australia (figure 13). The bore, usually slightly conical, is about 4 to 5 centimeters in diameter at the near end and up to 13 centimeters at the far end. The wall is 5 to 10 millimeters thick. Commonly encountered names of the instrument are *bambu* ʻbamboo' (throughout northern Australia), *kulumbu* (Kimberleys), *kanbi* (Western Arnhem Land), *djalapu* (Central Arnhem Land), and *yidaki* (Eastern

Performers blow into the didjeridu with loose lips to sound the fundamental as a drone. In Central and Eastern Arnhem Land, by tightening the lips and increasing the air pressure, players sound an overblown note a tenth to an eleventh above the fundamental; the exact interval varies from instrument to instrument. Except in some metrically free styles in Central Arnhem Land, the drone on the fundamental articulates rhythmic and metric patterns through the mouthing of vocables into the instrument. Some of these vocables—*didjeridu-didjeru, didjemro-didjemro, didjeramo-rebo didjeramo-rebo*—suggest how the instrument may have acquired its English name (Moyle 1967:3–4).

Further patterning of the drone occurs as a result of circular breathing: the player snatches breaths through his nose while expelling air held in his cheeks. The expulsion of air creates pulsations, tonal variations, and slight rises in pitch, further patterning the drone. Perhaps the most spectacular patterning is found in Eastern Arnhem Land, where complex patterns involving lightly spat overtones are produced in virtuosic displays (Moyle 1967:2B, with mouth sounds recorded separately). To mark structural points (such as the beginning or end of sections of a song), or to produce variant patterns that mark off internal formal divisions, players produce sustained overtones. In unmeasured styles (such as *ngarkana,* used in the central Arnhem Land clansong series *Murlarra*), the didjeridu sustains unpatterned notes of irregular length, and introduces overblown hoots at important structural points.

Songs of Central-Eastern Arnhem Land use overtones in both ways described above, but *wangga* and *lirrga* make no use of overblowing. There, a major technical element is the humming of a tone near the pitch of the second harmonic to produce a complex chord, rich in harmonics. With this technique, performers articulate rhythmic patterns typical of Western Arnhem Land. Special patterns may cue metrical changes in *wangga* (Marett and Barwick 1993); in Western Arnhem Land, where the didjeridu stops before the voice, players use terminating formulas with their own mouth sounds (Marett 1991). In Western and Central Arnhem Land, the pitch of the drone normally coincides with the final of the singer's melody. Didjeridus used in *wangga* and *lirrga* are usually shorter and higher in pitch than those used in clansongs of Central Arnhem Land. Longer, deeper-pitched instruments are used in Eastern Arnhem land, where players apparently do not try to match the pitch of the didjeridu with that of the singer's voice.

Players may perform standing or sitting. For parts of ceremonies that involve procession, they often stand or walk. Postures while sitting vary between Western and Central-Eastern Arnhem Land: in the west, where the didjeridu is shorter, the player holds the far end of the instrument off the ground, or supports it on his foot, resting his right arm on his raised right knee, supporting the didjeridu on his wrist or holding from below; in Central-Eastern Arnhem Land, the player rests the far end on the ground, or places it in a resonator (such as a bucket or a large seashell), and in time with clapsticks may tap the tube with his fingernail or a stick. —ALLAN MARETT

Acoustics

The basic sound of a didjeridu is a drone, which a performer elicits by buzzing his lips into the tube. At the frequency of this drone, the instrument acts approximately as a quarter-wavelength resonator. (The flare of the tube sharpens its resonance slightly.) This frequency ranges from about 60 hertz (about B_1) for longer instruments, to about 90 hertz (about F_2) for shorter ones. The player can also produce the second mode of the tube. Its frequency, a little less than 1.5 times the fundamental (this figure depending on the flare), sounds a rather flat twelfth above the drone (Fletcher 1983, 1996).

Despite the inharmonicity of these resonances, the steady sound of the didjeridu

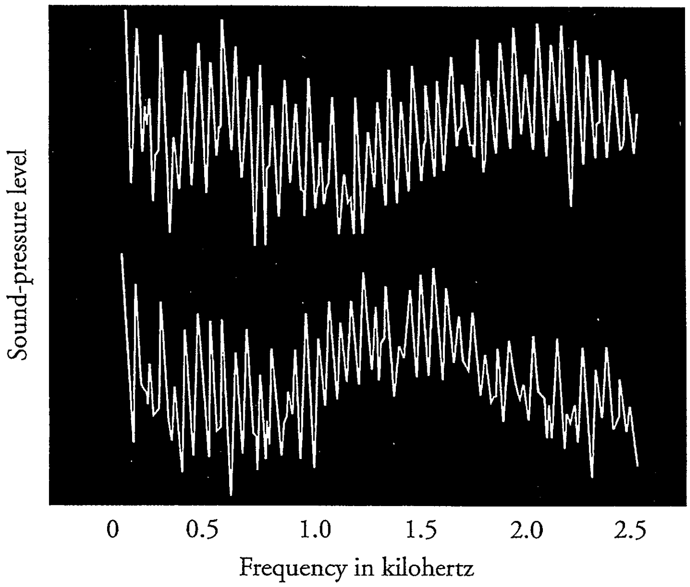


FIGURE 14 Frequency analysis of two versions of the steady drone of a didjeridu, showing the evenly spaced harmonics. In each graph there is a formant band near 500 hertz. There is a higher formant band near 2 kilohertz in the upper curve and 1.4 kilohertz in the lower. The player accomplishes this frequency shift by changing the effective volume of his mouth. Measurement by Neville H. Fletcher.

(figure 14) consists of a series of strictly harmonic overtones, as with all sustained-tone instruments unless they are playing multiphonics. Because of the form of the air pulsating past the player's lips, the acoustic spectrum of the drone is moderately rich in harmonics. The acoustic-power output of a didjeridu is comparable with that of other wind instruments, around a milliwatt. The player usually keeps the dynamic level constant, apart from rhythmic pulsations.

Special effects

Many of the acoustic effects of the sound of a didjeridu derive from the absence of a constriction, such as a mouthpiece. This absence causes the column of air to couple closely to the player's vocal tract. The player can markedly change the timbre of the sound by moving his tongue and cheeks to tune his oral cavity. Such actions emphasize harmonics of the frequency of the drone within a formant band determined by the volume of the oral cavity. This band typically lies in the range of 1,000 to 3,000 hertz (the range of human whistling), and bears a strong analogy to one of the formants that characterize the sounds of human vowels. Rapidly tuning the formant frequency produces impressive timbral effects. There is also a lower formant, with a frequency around 500 hertz, corresponding to the resonance of the lower vocal tract.

Playing a didjeridu uses a lot of air. To prolong the drone almost indefinitely, players use circular breathing: while storing air in distended cheeks, they suddenly inhale through the nose. This technique yields a marked pulsation, with a period between one and two seconds. Players usually decorate this pulsation by rhythmically articulating syllables such as *ri-to-ru* (with a rolled /r/ and a long /u/) or *did-je-ri-du.* In addition to these articulations, players often vocalize while playing.

Because vibrations of the lips and vocal folds affect the flow of air into the instrument in a multiplicative, rather than an additive, way (vocal folds and lips have to be open before any air will flow), the voiced sound does not simply add to the sound of the drone, but modulates it to produce sum and difference frequencies. If the frequency of the drone is f_1 and the player sings a frequency f_2, he produces frequencies $(nf_1 \pm mf_2)$, where n and m are whole numbers. Thus, if he sings a note a major tenth above the drone ($f_2 = 2.5 \times f_1$), he produces a strong difference-tone of frequency $0.5 \times f_1$, an octave below the drone. For a major third ($f_2 = 1.25 \times f_1$), the result is $0.25 \times f_1$, two octaves below the fundamental. These tones are unsubtle; because they have high harmonic content, they have a strident quality.

Players may use many additional vocal effects to mimic the sounds of wild animals. In such cases, the voiced sound usually has a much higher pitch than the drone. The difference frequencies are then unnoticeable, and the sound seems superimposed upon the drone.

Since the didjeridu is made from hardwood and is hollow, its mechanical resonances—basically deformations of the walls of the tube—are also musically useful. A player can excite these resonances by hitting the instrument with a stick, rhythmically embellishing the drone. —NEVILLE H. FLETCHER

Studio technology

Once heard only in the music of Arnhem Land and eastern Kimberley, and now heard as a feature of Australian Aboriginal popular music, the didjeridu has become an ingredient of worldwide musical genres: rock, jazz, new age, and symphonic music. For internationally released recordings in these genres, commercial studios have attracted such Aboriginal performers as David Hudson, Richard Walley, and Makuma Yunupingu, and such non-Aboriginal performers as Stewart Dempster, Andrew Langford, and Charlie McMahon.

The didjeridu may look and sound simple, but is neither, as musical instrument or sociocultural artifact. The use of nontraditional materials, such as polyvinyl plastic pipe or resins, and the electrical manipulation of recorded acoustic impulses are affecting its dissemination into new musical and geographic domains. Throughout the twentieth century, technology has driven the evolution of the entertainment industry, of which nonsacred didjeridu music is a part. In the context of popular musical genres, studio handling of the didjeridu involves recording, remixing, and reshaping.

Recording

The didjeridu produces a wide signal, involving a deep drone and one or more prominent overtones. A large-diaphragm microphone best captures these qualities, especially with large instruments. Also helpful are using a large area to add natural ambience, and using a medium level of compression to attenuate the width of the signal. Placing the microphone off the floor directly in front of the far end of the instrument results in a full sound, but often with noticeable attack in the form of the performer's breathing—an inherent part of the performance, which some listeners find intrusive. An alternative method is to position the microphone off to the side. Different microphone techniques suit different goals of production, such as where the didjeridu is to appear within the soundscape of the recording, and which other instruments complete the ensemble. In live applications, technicians commonly use various techniques of placing the microphone. One is to suspend the microphone over the far end of the instrument; this technique has the advantage of controlling feedback. Another technique is to set a microphone directly on the floor. Placements vary according to whether the performer sits or stands.

Remixing

When vinyl was the principal means of recorded reproduction, the didjeridu was best located in the middle of an ensemble. If placed elsewhere, its signal overpowered others, creating difficulties in mastering. Formats using tape and CDs have eliminated this problem, so placement is more flexible—such as off to one side when responding to a centered vocal or instrument. In live applications, perspective is also important, especially since the didjeridu occupies the same tonal register as the string bass and the bass drum. Placing it off to one side can help keep these instruments from setting up competing sound waves. For onstage monitoring, large woofers are best.