Chapter 8

Resonation

The Nature of Resonators

Resonation is the process by which the basic product of phonation is enhanced in timbre and/or intensity by the air-filled cavities through which it passes on its way to the outside air. Various definitions related to the resonation process include such terms as amplification, enrichment, enlargement, improvement, intensification, and prolongation, although in a strictly scientific usage acoustic authorities would question most of them. The main point to be drawn from these terms by a singer or speaker is that the end result of resonation is, or should be, to make a better sound.

In a technical sense resonance is a relationship that exists between two bodies vibrating at the same frequency or a multiple thereof. In other words, the vibrations emanating from one body cause the other body to start vibrating in tune with it. A resonator may be defined as a secondary vibrator which is set into motion by the main vibrator and which adds its own characteristics to the generated sound waves.

There are two basic kinds of resonance–*sympathetic* and *conductive*.[1] The essential difference between them lies in what causes the resonator to start vibrating. In sympathetic resonance (which is also called free resonance) there is no physical contact between the two bodies. The resonator starts functioning because it receives vibrations through the air and responds to them sympathetically. In conductive resonance the resonator starts vibrating because it is in physical contact with a vibrating body. This type of resonance is also called forced resonance, because the resonator is forced to vibrate.

Both types of resonance are at work in the human voice. When you are singing, much of the vibration that you feel is the result of conductive resonance. The vibrations created by the vocal folds travel along the bones, cartilages, and muscles of the neck, head, and upper chest, causing them to vibrate. There is little evidence that these vibratory

[1] For more detailed information on resonance, see the list of books on acoustics at the beginning of Chapter 2.

sensations make any significant contribution to the external sound, for reasons to be given later.

These same conductive vibrations, however, are good sensation guides for the singer, regardless of their effect on the external sound. These sensations provide evidence to the singer that his vocal folds are forming strong primary vibrations which are being carried from them to the head and chest. Thus these vibratory sensations can supply feedback about the efficiency of the phonatory process.

What a person listening to you hears, however, is mainly the product of sympathetic resonance. Vibrations created by the vocal cords travel through air from the larynx into the cavities of the throat and head, setting them into vibration. This is sympathetic resonance, for there is no physical contact between these cavities and the vocal cords. Vennard makes the point that the vocal resonator is not a sounding board of some sort, as comparisons with stringed instruments would make it, but a column of air, whose shape is not only complex, but highly variable. He continues:

> Thus it may vibrate as a whole or in any of its parts. It should not be too hard to think of it as vibrating several ways at once. Indeed most vibrators do this, otherwise we would not have timbre, which consists of several frequencies of different intensities sounding together. Air is fully as capable of this as any other medium; indeed, the sounds of many diverse instruments are carried to the ear by the same air, are funnelled into the same tiny channel, and can still be heard as one sound or as sounds from the individual sources, depending upon the manner in which we give attention.[2]

Factors Affecting Resonators. There are a number of factors which determine the resonance characteristics of a resonator. Included among them are (1) size, (2) shape, (3) type of opening, (4) composition and thickness of the walls, (5) surface, and (6) combined resonators. The quality of a sound can be appreciably changed by rather small variations in these conditioning factors.

In general, the larger a resonator is, the lower the frequency it will respond to; the greater the volume of air, the lower its pitch. But the pitch also will be affected by the shape of the resonator–for example, whether it is conical, cylindrical, or spherical–and by the size of opening and amount of lip or neck the resonator has.

A conical resonator, such as a megaphone, tends to amplify all pitch-

[2] Vennard, *Singing*, 82.

es indiscriminately; this is why it fulfills its purpose so well. The pitch of a cylindrical resonator is affected primarily by the length of the tube. A spherical resonator will be affected by the amount of opening it has and by whether or not that opening has a lip. The following experiment should prove interesting:

> Find two bottles with the same shape but different sizes, such as a pint and a quart. Blow across their openings and see which sounds the lower pitch. (The larger one should, because of its greater volume.) Now find two jars or bottles which have the same volume, such as pints or quarts, but have different size openings. A pint Coke bottle and a pint fruit jar would be ideal. Blow across both openings and see which has the lower pitch. (It surprises most people to discover that the smaller opening will produce the lower pitch. A bottle which has a longer lip than another of the same volume also will tend to sound a lower pitch.)

This experiment has some interesting implications for vocal technique that will be presented later.

Three factors relating to the walls of a resonator will affect how it functions–the material it is made of, the thickness of its walls, and the type of surface it has. The resonance characteristics of a musical instrument obviously will vary with different materials–wood, brass, tin, silver, lead, etc.–and the amount of the material used (the thickness) will have some effect.

Of special importance to singing is the relationship of the surface of a resonator to its tonal characteristics. Resonators can be highly selective–meaning that they will respond to only one frequency (or multiples of it)–or they can be universal–meaning that they can respond to a broad range of frequencies. In general, the harder the surface of the resonator, the more selective it will be, and the softer the surface, the more universal it will become. Hardness carried to the extreme will result in a penetrating tone with a few very strong high partials. Softness carried to the extreme will result in a mushy, nondirectional tone of little character. Between these two extremes lies a whole gamut of tonal possibilities.

E.W. Scripture experimented with resonators of different materials, including a simulation of the fleshy texture of the walls of the human resonators. According to Vennard, he showed that a hard resonator will respond only when the vibrator contains an overtone that is exactly in tune with the resonator, while a soft resonator permits a wide range of fundamentals to pass through undampened but adds its own frequency

as an overtone, harmonic or inharmonic as the case may be.[3] This also has some implications which will be discussed later.

The final factor to be mentioned is the effect of joining two or more resonators together. This is a complicated area, but in general it may be said that the effect will be to lower the resonant frequency of each in different proportions according to their capacities, their orifices, and so forth. The rules governing combined resonators apply to the human voice, for the throat and mouth and sometimes the nose function in this manner.

The next step will be to list the possible vocal resonators which might affect the sound of a singer and to evaluate them as to their location, adjustability, and possible contribution as judged by their resonance characteristics.

THE VOCAL RESONATORS

There are seven areas that may be listed as possible vocal resonators. In sequence from the lowest within the body to the highest, these areas are the chest, the tracheal tree, the larynx itself, the pharynx, the oral cavity, the nasal cavity, and the sinuses.[4]

THE CHEST. Although strong vibratory sensations may be experienced in the upper chest, and although numerous voice books refer to chest resonance, the chest, by virtue of its design and location, can make no significant contribution to the resonance system of the voice. The chest is on the wrong side of the vocal folds and there is nothing in the design of the lungs that could serve to reflect sound waves back toward the larynx. If you were trying to construct a good resonator, one of your last choices would be the spongy matter comprising the inside of the lungs, which would tend to absorb rather than reflect.

Place the palm of one hand firmly on your upper chest and say one of the following: "boom, boom, boom" or "mum, mum, mum, mum," prolonging the final [m] in each work. Repeating "ding" or "ninety-nine" will work well, also. The vibrations which you feel under your hand result from conductive resonance and reach a dead end (cul-de-sac) in the chest. Vennard refers to them as wasteful vibrations because they contribute so little to the external sound. However, they can be used to supply feedback to the singer. It must be concluded that the chest is not an effective resonator.

THE TRACHEAL TREE. The trachea and the bronchial tubes combine to form an inverted Y-shaped structure known as the tracheal tree. It lies just below the larynx, and, unlike the interior of the lungs, has a def-

3. Vennard, *Singing*, 85.
4. For a more detailed discussion see Vennard, *Singing*, 85-96.

inite tubular shape and comparatively hard surfaces. The internal diameter of the tube can be increased or decreased to a moderate extent (as in labored inhalation or coughing), but this is not under conscious control, so for all practical purposes the size and shape of the tracheal tree are not adjustable during the act of singing. This means that the response of the tracheal tree will be the same for all pitches except for its own resonant frequency. When this resonant frequency is reached, the response of the subglottic tube is to act as an acoustical impedance or interference which tends to upset the phonatory function of the larynx.

Research by Van den Berg has placed the resonant frequency of the subglottal system (the tracheal tree) around the E-flat above middle C for both males and females, varying somewhat with the size of the individual.[5] This coincides with one of the transition areas discussed in Chapter 7 (See Fig. 5.), where it was mentioned that both men and women may encounter problems between middle C and the G a fifth above it.

It is this writer's opinion that this problem is caused by the resonant frequency of the tracheal tree, which creates acoustical impedance and interferes with the normal phonatory function of the larynx. This interference will continue until the singer learns to adjust the supraglottal resonators (the ones above the glottis) to compensate for it. If this is true, there is no need to consider this problem area as a change of registers; it is an area of resonance adjustment, and modal voice can properly be used on both sides of it and during the adjustment.

The tracheal tree makes no significant contribution to the resonance system except for a negative effect around its resonant frequency.

THE LARYNX. Since the larynx contains the vocal cords, which function as the primary vibrator, the fact that it may also serve as a resonator could pass unnoticed. However, it is a cavity, although a rather small one, and therefore should be evaluated. If it is a resonator, it would function only for high frequencies, due to its size. Research by Bartholomew[6] and others has indicated that one of the desirable attributes of good vocal tone is a prominent overtone lying between 2800 and 3200 Hertz, with male voices nearer the lower limit and female voices nearer the upper. This attribute is identified as brilliance, or more frequently as "ring." More recently this overtone has become known as the *singer's formant.*[7]

There are several areas in or adjacent to the larynx which might resonate such a high pitch. Among them are the collar of the larynx, the

5. J.W. Van den Berg, "On the myoelastic-aerodynamic theory of voice production," *The NATS Bulletin* (May 1958).
6. Bartholomew, *Acoustics*, 145-147.
7. See discussion of singer's formant later in this chapter.

ventricles of Morgani (the pockets between the true and false cords), the vallecula (the space between the tongue and the epiglottis), and the pyriform sinuses (between the collar of the larynx and the thyroid cartilage). Another more distant area is that between the faucial pillars and the back wall of the pharynx.

Vennard seems to feel that "ring" is more likely to come from the vibrator itself than from a resonator–that the conditions under which it appears are more related to vocal fold action than to resonance. He make these comments:

> In any case, it appears that what is commonly called "getting resonance in the voice," is really getting "2800," and this is fully as much a matter of proper vibration as it is proper resonance. Also, even if it is really resonance, it is in some small cavity below the level of consciousness, which is only controlled indirectly, largely by ear. We cannot relegate it to indifference, however, because it does appear in some tones and not in others, and any means that will build it, no matter how indirect, must be taught.[8]

Johan Sundberg states that as early as 1934 Bartholomew suspected that the laryngeal tube played an important role in the generation of the singer's formant, and affirms that he shares that opinion.[9]

There has been some considerable research relative to the various cavities in and around the larynx, with some of the most interesting work centering around the ventricles and the pyriform sinuses, but nothing definitive has emerged as yet. All that can be said at this point is that the larynx is not under conscious control, but whatever produces "ring" can be encouraged indirectly by awareness on the part of the student and the teacher of the sounds which contain it.

THE PHARYNX. By virtue of its position, size, and degree of adjustability, the pharynx (throat) has to qualify as the most important resonator. It is the first cavity of any size through which the product of the laryngeal vibrator passes; the other supraglottal cavities have to accept whatever the pharynx passes on to them. Greene states:

> The supraglottic resonators being in the main muscular and moveable structures must be voluntarily controlled to produce conditions of optimal resonance either by varying degrees of tension in their walls, or by alterations in the size

8. Vennard, *Singing*, 90.
9. Sundberg, *Science of Singing Voice*, 120-121.

of their orifices and cavities during the articulatory movements.[10]

The pharynx is ideally suited to function in this capacity. Its vertical and horizontal dimensions can be increased or decreased, the tension in its walls is highly variable, and the size of the orifices leading to the mouth and nose can be varied, as can the entrance to the larynx itself. Because of its size, the pharynx is capable of bringing out the lower partials of the vocal tone when it is properly used. The resulting quality is described by terms such as fullness, roundness, warmth, richness, or mellowness. Various authorities place the frequency range of the pharynx somewhere between 330 Hz and 750 Hz.

The pharynx extends all the way from the back of the nose down to the larynx and the mouth of the esophagus. Three large bands of constrictor muscles form its walls–the upper, middle, and lower constrictors. The upper portion of the pharynx is called the naso-pharynx; it can be shut off from the rest of the pharynx by the action of the upper constrictor and the elevation of the soft palate. The part directly behind the mouth is called the oro-pharynx, and the lower part, the laryngo-pharynx. The laryngo-pharynx can virtually be cut off from the rest of the pharynx by the juxtaposition of the back of the tongue and pharyngeal wall.

The Oral Cavity. The oral cavity or mouth is second in importance only to the pharynx. It, too, is well-suited by location, size, and adjustability to serve as an effective vocal resonator. Its dimensions are altered by movements of the tongue, soft palate, jaw, and lips, and the shape and size of both its front and back orifices are capable of alteration. The main functions of the mouth are to form the vocal tone into understandable units by supplying consonants for communication, to get the sound out where it can be heard, and to join with the pharynx in the formation of vowel sounds.

Vennard says that the function of the mouth is to shape the tone into words, and the skill one must acquire is that of articulating without spoiling the quality which has been generated in the larynx and resonated by the pharynx,[11] while Greene sees it from another perspective:

> Possibly the most important function of the front resonator is the provision of a funnel for the projection of sound, like a speaking trumpet or megaphone. The more open this funnel can be kept by the relaxed position of the jaws and tongue and the lips the better projection the voice will have.[12]

10. Greene, *The Voice*, 70.
11. Vennard, *Singing*, 93.

The Nasal Cavity. The nasal cavity or nose is third in rank in the hierarchy of vocal resonators; it is much less important than the pharynx and mouth, being essential for the production of only three sounds in the English language–the nasal consonants [m], [n] and [ŋ], and the nasalized vowel sounds of languages such as French and Portuguese. Aside from a slight change in dimension effected by flaring the nostrils (which can make a singer look afflicted if done too assiduously), the cavity itself is not adjustable. However, it can be switched in or out of the resonance system to varying degrees by the action of the soft palate and the related musculature. The opening between the back of the mouth and the back of the nose is referred to as the nasal port.

The design of the nose is ideal for its main purpose: cleaning, adjusting the temperature of, and adding moisture to the incoming air. The factors which make it ideal are counterproductive for resonance. Like the inside of the lungs, the interior of the nose has little to recommend it as a resonator.

Research by Wooldridge, Vennard, and others has confirmed that it is necessary for the nose to function as a resonator only on the nasal consonants and vowels previously mentioned. Expert auditors were unable to distinguish between sounds made by singers with normal nostrils and the same singers with their nasal passages stuffed full of cotton gauze, and the vowel spectra revealed no significant differences. This means that the vibratory sensations experienced in the roof of the mouth, the nose, the cheek bones, or the sinuses by many singers may feel good and may provide evidence of a good sound, but contribute nothing to the external sound being produced. If they did contribute anything, blocking the nasal passages with gauze would alter the sound, which it did not. Like the chest vibrations, they may supply valuable feedback, but that is about all.

Authorities are not in complete agreement as to the nature of the transmission of these vibratory sensations. There is some feeling that the vibrations are carried to the bony structures of the head by conductive resonance, but others feel that the nasal cavity is made to vibrate sympathetically by the vibrations of the hard and soft palates, even when the nasal port is closed. These vibrations may testify to a good phonatory process or to the fact that the pharynx and mouth are functioning effectively as resonators, but, if so, it should be remembered that the vibrations are a *result*, not a *cause* of the sound you are producing.

12. Greene, *The Voice*, 73.

Vocal authorities differ as to how much nasal resonance, if any, is acceptable on sounds other than the nasal consonants. More about this later.

THE SINUSES. Because of their size, location, minuteness of orifice, and lack of adjustability, the sinuses cannot exert any significant influence on the vocal tone. In the past, various theories have attached great importance to the sinuses as resonators and even as the source of vocal tone (!), but research similar to that carried out on the nasal cavity has confirmed that their contribution to the external sound is negligible, despite all the wonderful vibratory sensations which may surround them. The singer should be aware of these sensations and even encourage them; but should know, as stated earlier, that they are the result of the sound being produced, not the cause.

SUMMARY. There are at least seven possible vocal resonators. Two of them–the chest and the sinuses–make no significant contribution to the external sound, despite the vibratory sensations which may be experienced in those areas and the considerable importance assigned to them in earlier days.

Two others–the tracheal tree and the larynx itself–have some effect on the external sound, but are not under conscious control and are considered of secondary importance. The tracheal tree exhibits the same response for all pitches except its own resonant frequency, where it tends to create a negative effect through acoustical impedance.

The larynx may be the source of "ring" in the voice (2800-3200 Hz), either through its vibratory pattern or a small cavity such as the collar of the larynx.

The most important resonators of the human voice are the pharynx and mouth, and, in a more limited sense, the nasal cavity. The nasal cavity is necessary for the production of the three nasal consonants in the English language and some nasalized vowels in other languages. It is not adjustable, but it can be switched (shunted) in or out of the resonance system to varying degrees by the action of the soft palate (velum) and related musculature. Vocal authorities differ as to how much nasal resonance, if any, is acceptable on sounds other than the nasal consonants. This will be considered more fully later in this chapter in a discussion of nasality.

The pharynx and mouth, because of their location, size, and degree of adjustability, must be considered the most important resonators, with the pharynx having a slight predominance because it gets the first shot at the laryngeal product. The pharynx is capable of bringing out the lower partials of the vocal tone, thus imparting a quality variously described as full, warm, round, rich, or mellow. The mouth helps to

shape the vocal tone into understandable units for communication by supplying consonants and has a function somewhat like a megaphone in transmitting the vocal sound outside the body.

The mouth and pharynx work cooperatively in the formation of vowel sounds, functioning as combined resonators in a highly variable and complex system, with constantly changing apertures, capacities, and degrees of firmness in the walls in moving from one vowel to another. A third resonator, the nasal cavity, is shunted in or out of the resonance system as the necessity arises for nasal consonants or vowels.

ADJUSTING THE RESONATORS

There are certain optimal conditions in the vocal resonators that must be sought after and established if the resonators are to function effectively. These conditions are related to such factors as laryngeal position, dimensions of the resonators in use, and size and/or type of opening. There also are certain thought patterns and physical actions that may be helpful in establishing these optimal conditions for the singer.

THE POSITION OF THE LARYNX. The mechanism of the larynx was presented in Chapter 5. The extrinsic muscles of the larynx perform the important task of positioning the larynx by raising, lowering, or stabilizing it. These muscles may be divided into two groups: those that originate above the larynx (the supralaryngeal muscles), and those that originate below the larynx (the infralaryngeal muscles).

As a general rule, those that originate above the larynx pull up on it, and those that originate below pull down on it. Both sets of muscles can play a part in stabilizing the larynx through the principle of muscular antagonism. The downward-pulling muscles often are called the yawning muscles, and the upward-pulling ones are rather loosely called the swallowing muscles or the chewing and swallowing muscles. The opposing action of the two sets can be illustrated by starting to yawn and then trying to swallow. The swallow cannot take place until the yawning muscles have stopped pulling down.

Most authorities now agree that the best position for the larynx is a comparatively low one, and that the larynx does not need to make any significant excursions up or down once phonation has started. These conclusions were reached through a series of tests designed to establish a relationship between desirable vocal tone and laryngeal position. It soon became apparent that the type of vocal tone favored by many teachers was associated with a comparatively low larynx, and that an undesirable type of tone often was associated with a high larynx. The scientifically-controlled tests only confirmed what many teachers had arrived at empirically: that a high larynx and a tight, edgy sound often occur simultaneously.

Granted that a comparatively low larynx position is correct, how can you determine when it is low enough? The following experiment, which is repeated from Chapter 5, should be helpful:

> Place an index finger gently on the notch of your larynx. Observe what happens when you *begin* to yawn. You will feel the lower jaw drop freely open, the larynx descend slightly, and a gentle lifting in the area of your soft palate, as cool air goes deep within your throat and lungs.
> Now continue the action until it becomes a full yawn, noticing the tension which develops in the throat and the jaw joint (temporomandibular joint or TMJ).
> Experiment with trying to speak or sing (1) in the beginning-of-a-yawn position, and (2) in the full-yawn position. You will discover that the first position is conducive to easy phonation, while the second is somewhat antagonistic to it.

The beginning-of-a-yawn position is ideal for singing and should be cultivated. The full-yawn position is exaggeratedly low and should be avoided; it is known as the depressed larynx.

Granted that the beginning-of-a-yawn position of the larynx is ideal for phonation, what does it have to do with resonance? Both the size of the pharynx and the tension in its walls are affected by the location of the larynx. When the larynx is high, the length of the pharynx is diminished, its walls are made harder and its horizontal dimensions are decreased by the action of the constrictor muscles. All of these actions tend to restrict the resonation capabilities of the pharynx.

The "Open" Throat. Many writers concur on the value of an "open" throat; there is not as much agreement on what it is or how it should be achieved. Apparently some are referring to the vertical dimensions (a deep or long throat), others to horizontal expansion (a large throat). What are the desirable attributes of the "open" throat? There are several:

1. sufficient size to bring out the low partials,
2. sufficient flexibility to adjust (tune) to different pitches coming from the larynx,
3. sufficient softness to absorb undesirable high partials and respond to a broad range of pitches, and
4. sufficient muscle tonus to preserve the character of the tone.

If sufficient space is to be maintained in the pharynx, the swallowing muscles must not be allowed to take over. Their main functions are to raise the larynx and to make the throat as small as possible, so that food or drink may be squeezed into the esophagus. Start to swallow and try to phonate at the same time; you will quickly discover that the two processes are antithetical. One of the main causes of bad vocal sounds is tensing the constrictor muscles; it hardens the resonator walls, reduces needed space, and tends to create tension in the primary vibrator– the vocal folds. All of these results are contributory to a tight, hard, pressed sound.

The attempt to maintain space in the pharynx should not result in local effort, forcibly holding the throat expanded, or locking the jaw open. These actions are just about as harmful to the sound as singing with a high larynx. Singing in the full-yawn or depressed larynx position is an example of artificially maintaining pharyngeal space, which results in a great deal of tension.

The ideal way to arrive at a proper concept of the "open" throat is by learning to maintain the beginning-of-a-yawn position. The beginning of a yawn is not a panacea for all vocal ills, but it is a helpful stimulus to all four of the physical processes involved in the singing act, and should not be dismissed lightly. Sometimes a natural solution to a problem is overlooked because it seems too simple or inconsequential. Analyze the beginning of a yawn carefully and you will find that it can accomplish all of the following:

1. opens the pathway for a noiseless and almost effortless taking in of air;
2. positions the larynx in a comfortably low position, without tensing to do so;
3. increases the size of the throat, especially in the vertical dimension, by lowering the larynx, gently lifting the soft palate, and relaxing the constrictor muscles of the pharynx wall;
4. relaxes the muscles controlling the articulators, thus freeing them for action.

There are few situations where a singer can get so many beneficial results with so little expenditure of effort.

The Position of the Soft Palate. Students are often confused about the position and functions of the soft palate. According to Greene:

> The velum is an entirely muscular flap attached to the hard

> palate anteriorly and hanging free posteriorly, terminating in the uvula.... It is composed of several paired muscles, some fibres of which are inserted in the tongue and others in the pharynx.[13]

When at rest the soft palate hangs down almost vertically. This leaves the nasal port open, and the naso-pharynx forms a continuation upward of the oro-pharynx. In order to close the nasal port and cut off the nasal cavity, the soft palate must be elevated until it makes contact with the back pharyngeal wall. This closure is more or less complete depending on the vowel to be sung and perhaps the tonal preference of the singer.

The soft palate assumes its highest position (most complete closure) on the vowel [i], but also elevates considerably for the plosive consonants. On the nasal consonants the soft palate is down and the nasal port is open; this adds the nasal cavity to the resonance system. In swallowing, the nasal port is completely closed to prevent food or drink from being pushed into the naso-pharynx.

It is easy to observe the raising and lowering action of the soft palate (especially of the uvula) in a hand mirror. Try singing an arpeggio to the upper octave and back down to the original tone while watching the uvula.

The External Orifice. The main discussion of the articulators will be reserved for the following chapter, but mention needs to be made here of their effect on the external orifice of the resonation system. For example, what effect will the lips have on the external sound if they are moved? Try these experiments:

1. Pull your lips back into a forced smile and sing the vowel [ɑ]; it is difficult to keep the sound from sounding hard and too bright. Pull your lips back hard again and notice the tension it creates in the region of the soft palate; you may feel a tightness around the larynx, too.
2. Now pull your lips in over your teeth until your mouth is almost closed; notice how it muffles and darkens the sound, and also changes the vowel.
3. Now protrude the lips forcibly until the front teeth are uncovered and you feel tension in the back of your throat and around the base of your tongue. Try to sing the [ɑ] vowel; notice how tense it feels and how brilliant it sounds. Uncovering the teeth tends to encourage the high partials, and "trumpeting" the lips tends to lock the resonance system into a tight sound of considerable brilliance but little beauty or flexibility.
4. While singing in this protruded lip position, relax your lips and open your jaw freely. Observe the almost startling contrast in tone quality and ease of production.

[13] Greene and Mathieson, *The Voice*, 37.

The purpose of these brief experiments has been to demonstrate the importance of the size and shape of the front orifice to the final vocal product, the sound that is leaving the body. Even if the rest of the resonance system is producing its best effort, the net result can be spoiled by the external orifice. The use of the mouth and lips will be discussed more fully in the next chapter, but for now it should be emphasized that the lips must avoid any rigid position; they should not be pulled back, pushed forward, or rendered almost immobile, but should be free to move at all times. The mouth should open freely, as in the beginning of a yawn, with the lower jaw dropping freely open, also.

The Singer's Formant. As was mentioned earlier, the larynx is not under conscious control. Considering the complexity of its structure and mode of operation, it probably is best that singers can not impose direct muscular control on the larynx. However, it must be recognized that the singer's formant plays a very important part in the ability of a singer to be heard over an orchestra. For this reason alone it is imperative that the student and the teacher be aware of the existence of a singer's formant and seek all indirect means of encouraging its presence.

According to Greene and Mathieson,

> This optimal frequency occurs at a bandwidth in which orchestral energy is low. As use is being made of optimal resonance the operatic singer is able to be heard without using excessive effort, above the apparently much greater volume of the orchestra.[14]

Sundberg states that since the singer's formant can be present in all sounds, it must be comparatively insensitive to vowel articulation. He also says that the laryngeal tube is the part of the vocal tract that varies the least with vowel articulation.[15] Among the conditions he has observed which seem to create a favorable environment for the generation of the singer's formant are (1) lowering of the larynx, (2) widening of the laryngeal ventricle, and (3) widening of the pyriform sinuses (the bottom part of the vocal tract surrounding the laryngeal tube). The

[14] Greene and Mathieson, *The Voice*, 56.
[15] Sundberg, *Science of Singing Voice*, 120.

beginning-of-a-yawn position which has been recommended throughout this book is conducive to all three of these conditions.

Faults Related to Resonation

The faults related to resonation may be divided into two major categories: (1) those related to nasal resonance, and (2) those related to the basic harmonic spectrum of a voice–its tone color.

Faults Related to Nasal Resonance. The faults related to nasal resonance also may be divided into two categories: (1) excessive nasal resonance (hypernasality), and (2) insufficient nasal resonance (hyponasality).

It has been pointed out that the only sounds in the English language which call for the addition of the nasal cavity to the resonance system are the nasal consonants [m], [n], and [ŋ]. Research has confirmed that all the other sounds can be formed acceptably with the nasal port closed or with the nasal passages blocked. Some authorities, such as Vennard, feel that the closure of the naso-pharynx should be complete for all sounds other than the nasal consonants. Others feel that a slight opening of the nasal port is not detrimental to the sound and may even add a desirable mellowness, while still others, such as Westerman, state that the soft palate should be lowered in singing.

One of the difficulties in discussing nasal resonance is reaching a consensus on how much of it is good and desirable, and what limit must be passed before it becomes excessive. Another difficulty is that there are two distinct, but closely related tone qualities that are identified as nasality. In some writings it is not easy to determine which type is being discussed. Perhaps the first step should be to attempt to clear away some of the confusion about these two types, before trying to decide how much nasal resonance is excessive.

True nasal resonance occurs when the nasal port is open enough for the nasal resonator to exert the *predominant* influence on the external sound produced. This occurs naturally in the nasal consonants, the French nasal vowels, and in a hum. If the nasal resonator is allowed to remain predominant in other sounds, however, it is classified as excessive nasal resonance or true nasality. It appears in an exaggerated form in cleft palate speech because the individual cannot close the nasal port completely enough with his soft palate to cut out the nasal cavity when it is not needed.

One suggested name for this type of nasality is **postnasality,** because the sound seems to be formed behind the nose; another is the descriptive expression apparently coined by William Vennard, **nasal honk.** In this true nasality the nasal cavity is coupled into the resonance system along with the mouth and pharynx, but dominates the tonal result.

There is a second type of nasality which may be identified as **forced nasality** or **nasal twang.** It is more widely recognized by the general populace as nasality than the true variety is, and is characterized by a tight, pinched sound which seems to be centered in the nasal cavity. Interestingly enough, true nasality may not be present with this sound, because nasal twang can be, and often is, produced when the nasal port is completely closed.

Modern research has confirmed the earlier findings of Paget that nasal twang is caused by constriction somewhere in the pharynx. This constriction either forms a small resonator of high pitch (possibly in the area of the palatopharyngeal pillars) or emphasizes a high partial through muscle tension, for researchers have found that nasal twang is associated with a high overtone somewhere in the range of 2500-2800 Hz. (Vennard has pointed out the proximity of this frequency range to that of the "ring" in the voice.) If the nasal port is open, postnasality (nasal honk) may be present also, but if so, it will tend to be covered up by the characteristic penetrating quality of nasal twang, in which the nose is forced to vibrate.

Now back to the question of how much nasal resonance is excessive. The majority opinion seems to favor a vocal tone for sounds other than the nasal consonants in which the nasal port is closed or only slightly open. Experiments have demonstrated that in some singers the closure of the nasal port is seldom complete and yet there may be no obvious nasality. The test of excessive nasal resonance must remain a subjective one for the individual listener, but there is a guideline for him to follow. If the sound indicates that the nose is the most obvious part of the resonance system on non-nasal sounds, nasality is present. If the ear cannot hear the predominance of the nose, nasal resonance may be present, but it is within acceptable limits.

When there is insufficient nasal resonance, the resulting sound is said to be *denasal.* It occurs when some physical condition or organic factor prevents the normal formation of the nasal consonants and limits nasal resonance in other sounds. The best illustration of this is the speaking voice of a person suffering from a bad head cold; a similar speech pattern can be caused by adenoids, a deviated septum, or polyps. Some persons without physical or organic problems adopt this mode of speech, but it is seldom a concern with singers. If it should appear, the best approach is humming exercises and vocalises centered around the nasal consonants.

Corrective Procedures for Postnasality (Nasal Honk).[16] Postnasality occurs when the nasal port is not sufficiently closed by the elevation of the soft palate and the nasal cavity predominates on non-nasal sounds. (The appearance of nasality in normally nonnasal sounds is

16. Listen to Band 5 of the cassette tape.

called assimilation nasality.) Aside from organic problems, the chief causes of postnasality are wrong tonal models and/or inactive palatal muscles. If there is any indication of organic problems, the student should be sent to a medical specialist. If not, both of the other possible causes should be investigated.

First of all, find out if the student is aware that he is making such a sound; if he is, see if there is a reason why–such as, a former teacher, tonal preference, easy to sing that way, etc.

Second, try to develop a new tonal model for him; demonstrate a postnasal sound and a balanced one, preferably by singing them or by recordings. Show him the tonal and dynamic limitations of the nasal honk.

Third, try to direct his tonal sensations to a new location. Explain that a balanced sound has a lot of hard palate vibration and seems to be centered more in the mouth, whereas a honk has more vibration around the soft palate and seems to be centered up behind the nose. Demonstrate the action of pulling the sound forward and down into the mouth from behind your own nose. Ask him to imitate what you are doing and to describe his own sensations; he may say something that will reveal what he is not doing.

If the postnasal sound persists, approach it from another direction while continuing the old one. Assume that the palatal muscles are inactive and start exercising them. It would seem logical to assume that you should avoid the nasal consonants since the sound is too nasal. Strange to say, the nasal consonants all are useful, for the reason that they require palatal movement, especially if they are formed vigorously. This is particularly true of the [ŋ].

Experiment with words like ding, gone, zoom, hung, bum, and voom, putting the initial consonant on quite firmly and sustaining the nasal consonant while repeating the same word several times. Even though nasal sounds are being used, palatal activity is being stressed. Sometimes the vigorous juxtaposition of a syllable ending in [ŋ] and one starting in [g] is effective, such as hung-gah or ding-gah. Plosive consonants, such as [p] and [b], are good because they require closure of the nasal port. Speech therapists incorporate various blowing exercises, such as blowing up balloons, for the same reason.

As a last resort, since postnasality can be caused by muscular inactivity, it may be assumed that the pharyngeal resonator is too flabby and needs more tension. Therefore the suggestion may be made for the student to produce a more twangy or even a tighter sound as an intermediate step on the way to a balanced one. The final step in the process would be the instruction, "Now let your lower jaw open wider and let the sound drop down into your mouth." Any approach of this kind is a

means to an end and should be used with caution. There is little gain in substituting one fault for another.

CORRECTIVE PROCEDURES FOR FORCED NASALITY (Nasal Twang).[17] Forced nasality is caused by constriction somewhere in the pharynx. Possible areas of the constriction include all three parts of the pharynx–the naso-pharynx, the oro-phayrnx, and the laryngo-pharynx. Margaret Greene states:

> ...it should not be forgotten that nasality may also be imparted to the voice by muscular constriction in the laryngeal cavity and the relative positions assumed by the ventricular folds, aryepiglottic folds and epiglottis, also elevation of the larynx by the suprahyoid muscles.[18]

Tension in the pharyngeal resonator, with possible involvement of the larynx itself, is the cause of the forced vibrations in the nose and the sound which is descriptively identified as nasal twang.

Another factor which may contribute to twang is the lack of oral space–the failure to provide enough mouth opening for the resonance system.

Any corrective procedure for twang must provide for eliminating unnecessary tension (constriction) in the pharynx and larynx, must help develop a new tonal model, and must encourage the use of more oral space. Faults resulting from tension, such as tight phonation from laryngeal tension and nasal twang from a constricted pharynx, often may be traced to a prior cause such as faulty breath support or posture. When one part of the mechanism fails to function as it should, another often must compensate for it. As a prelude to the elimination of twang, it would be wise to check first on posture, breathing, and support. Then try the following approach:

1. Use loosening-up exercises for the entire body first, as suggested in Chapter 3.
2. Use exercises designed to relax and loosen the neck, throat, and lower jaw–rolling the head around easily in circles, nodding the head, flopping the jaw loosely while saying "yah, yah, yah," or "mah, mah, mah;" practice the beginning of a yawn while inhaling.
3. Try to develop a new tonal model for the student; demonstrate and contrast a twangy tone and a balanced one. Caricature

17. Listen to Band 6 of the cassette tape.
18. Greene, *The Voice*, 240.

the twang and explain its tonal limitations.

4. Try to direct the student's tonal sensations to a new location. As he is sustaining a sound, ask him to open his mouth wider (drop his jaw open) while feeling the sound drop down from the front of his nose into his mouth. (Since the twang overtone is so close to that of "ring," you do not want to eliminate it, but to bring it into better balance with the rest of the resonance system. Providing more mouth space and more relaxation in the pharynx will help to do this.)

Perhaps the most important thing is establishing a new tonal model so that the student will be motivated to change the kind of sound he is making. Physiologically, the beginning of a yawn must be maintained to eliminate the constriction, the mouth must open freely to provide more oral space, and the sensation of a more mouth-centered tone must be cultivated.

FAULTS RELATED TO TONE COLOR. Aside from nasality, most of the faults related to resonation may be divided into two categories: (1) sounds that are classified as *too bright*–too white, too open, or too forward, and (2) sounds that are classified as *too dark*–too muffled, too swallowed, too covered, or too far back.

Both groups of faults result from a failure to bring the vocal resonators into proper balance. In the "too bright" group there tends to be too much emphasis on the mouth as a resonator and not enough on the pharynx. In the "too dark" group the situation is reversed; there is too much emphasis on the pharynx and not enough on the mouth. (In the faults related to nasality it was the nasal resonator which upset the desired balance.)

Although it is far from a unanimous choice, the tonal preference of most teachers seems to lie in a balanced sound–one which has both highs and lows present (both "tweeters" and "woofers"). If the lows are cut out of a sound, the result is a too white or too bright tone quality; if the highs are cut out, the sound becomes too dark or too dull (often referred to as a "tubby" sound). It is easy to demonstrate these tonal extremes on any high quality sound reproduction equipment by means of the treble and bass controls.

Most listeners like to have both ends of the harmonic spectrum present in a sound, but differ as to the desirable amount of each. The point of this discussion is to say that there is plenty of room in the broad middle ground of tonal preference for persons who like brighter or darker sounds. It is somewhat like flavors of ice cream; debate will never settle the question of which flavor is better; it comes down to individual

choice. Brightness and darkness are not in themselves vocal faults; they become faults when a majority would identify the sound as *too* bright or *too* dark.

A word needs to be said also about focusing, placing, or projecting vocal sound. The teacher who attempts to use these words in any literal sense may end up in a scientific quagmire. Sound moves out from its vibrating source in a series of compression and rarefaction waves, filling any vocal resonator to which it has access. There is nothing in the human mechanism by means of which a singer can place, focus, or throw the sound anywhere. And yet all these terms have meaning within the experience of both teachers and students.

Vennard refers to "the illusion of placement." The student feels vibratory sensations at certain places and discovers that when his teacher suggests moving the tone forward or backward, he can feel the sensations move. It is legitimate to call this "voice placement" if you understand that your sound actually has not been put anywhere.

Likewise, a student tries to sing so that he can be heard in the back row of a large auditorium by thinking about projecting his voice. He may succeed in his effort, not because he has thrown his voice anywhere, but more likely because he begins to phonate more efficiently and to tune his resonators better. The resulting sound may be heard more easily on the back row, but, strange to say, may not register any increase of decibels on a meter. It is possible to speak of "projecting your voice" if you understand that you really have not thrown or impelled it anywhere.

Finally, suggesting to a student that his voice lacks focus may help him to tune his resonators in such a way that the partial associated with "ring" (the singer's formant) may appear in his voice. He has not focused his voice anywhere, but the thought process has helped him make a more desirable sound. It is probably all right to use such terms as placement, projection, and focus in your teaching, but be careful not to confuse them with scientific fact.

CORRECTIVE PROCEDURES FOR SOUNDS THAT ARE "TOO BRIGHT."[19] The chief cause of sounds that are too bright is placing too much emphasis on the oral resonator. There are several factors which can cause this to occur: (1) lack of space in the pharynx due to the action of the constrictor muscles and/or elevation of the larynx; (2) tension in the walls of the pharyngeal resonator making it too selective; (3) wrong tonal models; (4) exaggerated mouth opening, pulling the lips back in a forced smile, or protruding the lips too much; (5) excessive tension in the muscles of the lips, tongue, jaw, or palatal arches.

19. Listen to Band 7 of the cassette tape.

The tight sounds of hyperfunctional phonation and their associated remedial procedures were discussed in Chapter 5. It should be noted that tight phonation often occurs in conjunction with too bright sounds. The tension which causes one tends to contribute to the other; therefore, any corrective procedure should begin with the elimination or reduction of tension. Try this approach:

1. After checking on posture, breathing, and support, use general body-loosening exercises (Chapter 3 or section on twang).
2. Use exercises designed to relax and loosen the neck, throat, and articulators.
3. Exercise extensive practice on establishing and maintaining the beginning-of-a-yawn position–the tension and constriction in the pharynx must be lessened.
4. Try to develop a new model for the student; contrast sounds that are too bright with balanced ones, explaining tonal limitations of such sounds.[20]
5. Since the vibratory sensations a singer feels can be moved around, suggest that he think the sound more inside himself, more internally, further back, or similar expressions which might call attention away from the mouth.
6. Most beginning singers need to imagine a deeper, richer, more dramatic kind of sound than they usually sing– direct his thoughts along these lines.
7. The back vowels, which require lip rounding (such as [ɔ], [o], and [u], are less tense than the frontal ones and more conducive to a darker sound; try combining them with the beginning-of-a-yawn feeling; precede them with [b], [m], or [j] to help reduce articulatory tension.

Sounds which are too bright often are associated with a high laryngeal posture. Some singers, particularly ones with lower voices, start with the larynx comparatively low and then raise it progressively as the pitch ascends, somewhat like an elevator (lift) moving from floor to floor in a department store. Other singers, chiefly ones with higher voices, tend to elevate the larynx as soon as phonation begins and force it even higher for the upper pitches.

There is nothing in the laryngeal mechanism which requires that the larynx raise as pitch ascends or lower as it descends, with the possible exception of the extremes of range and of minor height adjustments associated with different vowels. Research has revealed that there is little laryngeal movement in many well-trained singers.

When a singer has made high laryngeal posture a habit, it can be a difficult one to break. If possible, it is best to do so by adopting a new tonal model and trusting it to bring about laryngeal stability. If it does not, some type of physical reminder may be needed.

Ask the singer to place the tip of a finger gently on top of the thyroid notch and to observe when and how the larynx starts to rise. Ask him to counteract this tendency by mental controls, not by holding the larynx down with his finger, but by thinking that it does not need to move; the finger serves as a warning each time the larynx rises. Usually this awareness of movement will result in its elimination. If it does not, you must try to find at least one pitch in his voice on which there is no upward movement; alternate this pitch with the whole step above it until the larynx stays down for both pitches; then alternate the lower pitch with a major third until it is established, then a perfect fourth, and so on until the whole range is secure. This problem requires a great deal of patience from both the singer and the teacher, but it can be solved eventually.

Corrective Procedures for Sounds That Are "Too Dark."[21] The chief cause of sounds which are too dark is in placing too much emphasis on the pharyngeal resonator. There are several factors which can cause this to occur: (1) overuse of the "yawning" muscles, with resulting spread throat and/or depressed larynx; (2) lack of oral space due to lip, jaw, or tongue position; (3) wrong tonal models: (4) flabby surfaces of pharyngeal walls (not enough muscle tonus to give any character to the sound); (5) tongue pulled back into the pharynx.

Darkness in a sound can come from too much or from too little tension, so it is important to try to identify the specific causes before starting corrective procedures. Look first for lack of activity in the articulators, such as failure to move the lips or make any significant mouth opening; this can darken and muffle the sound even when no other faults are present. Such lack of movement usually is easily corrected by calling the student's attention to it and requiring him to practice in front of a mirror.

If this is not the problem, listen to the student's sound to see if it is breathy in addition to being dark. If so, it is best to work on the breathy sound first, since it is a phonatory problem. (For suggested techniques, see Chapter 5.) Often the darkness will disappear when the breathiness is eliminated.

20. Greene states, "...undue emphasis upon acquisition of resonance of imaginary origin in the air-filled spaces of the head may lead to an unpleasant thin and tinny quality to the voice and of course neglects the important principles of satisfactory voice production," 76.

21. Listen to Band 8 of the cassette tape.

Next, find out if the student is aware that he is making such a dark sound; if he is, see if there is a reason why–such as, he was taught to sing that way, he likes the sound, etc. Then, try to develop a new tonal model for him; demonstrate various sounds that are too dark and contrast them with balanced ones. Explain the tonal limitation of dark sounds. Then, try to direct his tonal sensations to a new location.

Explain that a balanced sound has a lot of hard palate vibration just behind the front teeth and seems to have a lot of mouth resonance, whereas a dark sound has more vibration near the back of the palate, and seems to be more centered in the throat. Try such suggestions as: bring your tone forward, sing outside of yourself, sing a brighter sound, try to feel vibration in the front of your face.

If you think that his tongue is being pulled back, ask him to stick his tongue out over his bottom lip and sing "ah" in that position; this is hardly an ideal singing position, but it will give him some new vibratory sensations. Singing with the tongue over the lower lip is a good countermeasure for a depressed larynx also, since the tongue, hyoid bone, and larynx are joined together in sequence. Exercises on the frontal vowels–such as [i], [ɪ] and [eɪ]–may help to brighten the sound, and rapid articulation exercises or patter songs may be beneficial, as well.

CLOSING SECTION. There are other matters which might be considered in a chapter on resonation. Chief among these are the vowels, which strictly speaking are phenomena of resonance; however, it is more convenient to consider them along with the consonants in the articulation chapter. Problem areas–such as the transition from chest voice into middle voice for women, and from chest voice into head voice for men–which likely arise from the resonant frequency of the tracheal tree, could be discussed here, but will appear in the final chapter, where problems of coordination will be treated. The phenomenon know as "cover," which is closely linked with adjustment of the resonators, also will be reserved for that chapter. The next chapter will deal with articulation and its related faults.

Chapter 9
Articulation

THE ARTICULATORY PROCESS

Articulation is the process by which the joint product of the vibrator and the resonators is shaped into recognizable speech sounds through the muscular adjustment and movements of the speech organs. The primary articulators are the movable ones–the tongue, the lips, the lower jaw, the soft palate, and, in a more limited sense, the glottis, the epiglottis, and the larynx itself. They work in cooperation with the teeth, the alveolar ridge, the hard palate, and the pharyngeal wall to form an almost infinite variety of speech sounds by altering the size, shape, apertures, and other physical characteristics of various parts of the resonance system.

Detailed discussion of the production and classification of speech sounds is beyond the scope of this book.[1] An introductory approach to the classification of vocal sounds was made in Chapter 2; the discussion here will be limited to the identifying characteristics of consonants and vowels, and the problem of phonemic identity.

THE NATURE OF CONSONANTS. The most important identifying characteristics of consonants are contained in these statements:

1. They are more or less restricted speech sounds.
2. They contain more or less conspicuous noise elements due to the degree of restriction present.
3. They are subordinate to vowels in sonority.
4. They do not form the center (nucleus) of syllables, but define the borders of them.
5. They function as sound interrupters or sound stoppers and thus separate the vocal tone into recognizable units which can communicate meaning.

Consonants may be divided into two groups–those which require vocal fold vibration (*voiced consonants* or sonants) and those which do

[1] Readers are referred to Wise, *Applied Phonetics*, and Virgil A. Anderson, *Training the Speaking Voice*, 3rd ed. (New York: Oxford University Press, 1977).