described the collective term *indeterminate* râles, regarding them as analogous to the indeterminate respiratory murmur, as neither class of phenomena offers any indication of the condition of the lung-tissue with respect to air-contents. Practised auscultators, nevertheless, are able to determine, from certain peculiar qualities of the non-uniform bubbling râles, whether they are due to a simple catarrh, or to the secondary catarrh dependent on condensation of the lung-substance. No general rules can be laid down for guidance to the formation of such a diagnosis, which is, indeed, rather a matter demanding skill and experience; it must suffice, therefore, to point out some of the principal differences between the râles of primary and of secondary catarrh. In simple bronchial catarrh the râles are heard over the greater part of one or both lungs, they vary greatly in intensity at different points, consisting of bubbles of very unequal size, and are usually accompanied by dry râles (see p. 158); the vesicular inspiratory sound, further, is generally of the rough, harsh type, and a characteristic thrill is often felt by the hand laid on the chest-wall. These details are applicable also to the bronchial catarrh associated with pulmonary emphysema. But the râles of secondary catarrh, catarrh consequent on condensation of the pulmonary parenchyma, are more limited in distribution, being frequently confined to small circumscribed spots; they are usually much finer,—as such catarrh most commonly has its seat in the smaller bronchi,—are more seldom accompanied by dry râles, and are very rarely, and then but feebly, appreciable to the hand placed on the surface of the chest.

5. Resonant and Non-Resonant (Toneless) Râles.

Resonant (or sonorous) râles are those in which a tone of somewhat musical quality is distinguishable, the non-resonant those which make on the ear the impression only of a non-musical sound or noise. The former usually appear to the ear *clear* and *high*, the latter *dull* and *low in pitch*; in well-marked, typical instances, therefore, the distinction between the two varieties is easily made, while in the transition-forms, which are designated, on the one hand, as *obscurely* or *approximately resonant*, or on the other as *almost toneless*, much has to be left to the subjective appreciation of the individual examiner.—All fine, coarse, or medium-sized bubbling râles, with the exception of the small *uniform* râle (the crepitant râle), may become resonant under certain circumstances described below.

Resonant râles arise only in consolidated lung-tissue and in cavities, and should therefore be interpreted in the same way as bronchial respiration; on the other hand, râles which originate in parts of *spongy* texture are invariably *non-resonant*.—The cause

of this resonance is to be found, not in Skoda's assumed consonance,* but in the favourable conditions offered by the dense tissue for the transmission of each individual sound to the surface. As the râle generally loses its resonant quality in passing through expansible, air-containing lung, it is usually toneless at some distance from its point of origination.—If in listening to a resonant râle special attention be directed to *individual* bubbles, it will be found that they do not all burst with the same musical sound, that many, in fact, are absolutely non-resonant; the more numerous the bubbles having the sonorous character the more distinct is the resonance; this resonance is also greater the more complete the consolidation of the lung, the closer the indurated part lies to the surface, and the larger the bubbles thrown up in the fluid. But it is far from being invariably the case that the râles heard in condensed lung-substance are resonant; they are sometimes perfectly devoid of the sonorous quality, this being specially apt to occur if the dense part is small, or if between the portions of solidified tissue the lung is still quite spongy in texture.

But frequently, with well-marked physical signs of consolidation,—percussion-dulness and loud bronchial respiration,—the râles may appear non-resonant, whilst at a subsequent examination they may again be distinctly resonant; this change does not in all cases admit of ready explanation.—The most clearly resonant râles are those generated in cavities situated close to the surface of the lung and surrounded by dense, firm parenchyma.

Thus, whilst *resonant* râles indicate with certainty the presence of *condensation* or *excavation* of the lung-tissue, *non-resonant* râles *do not necessarily exclude* the existence of these conditions. In the absence of the resonant râle the diagnosis of consolidation of the lung-substance rests on the results of percussion (dulness), and of auscultation of the respiratory sound (bronchial breathing). In those parts in which the râles are of resonant quality the respiratory murmur may be bronchial, or amphoric, or indeterminate, but obviously *never vesicular*.

The non-resonant râles, yielding, as they do, no direct evidence as to the condition of the lung-substance, fall naturally into the category of indeterminate râles already mentioned.—Sometimes, however, they bear no resemblance whatever to the

* Skoda names the resonant râle the *consonating* râle, in conformity with his view of its origin.

usual sound of bursting bubbles, being of a peculiar *creaking* or *crackling* quality. Such a râle, which constitutes the transition-form between moist and dry râles, indicates great swelling of the bronchial mucous membrane, and a scanty or very tenacious secretion. These creaking râles occur very frequently both in primary bronchial catarrh and in the catarrh which accompanies chronic induration of the lung.

As the apices of the lungs are the parts most commonly affected by condensation it is here that the creaking and crackling sounds,—more frequently the former,—are oftenest heard. These peculiar phenomena are observed only when the râles are scanty; they appear, also, to originate in the immediate vicinity of the ear, in the most superficial parts of the lung.—After remaining audible for a considerable period they may completely disappear, on account of diminution in the quantity of the bronchial secretion. In general their characters are subject to much variation, like those of all the other moist râles.

Metallic Râles.

The most exquisite form of the resonant râle is termed the *ringing, metallic râle.*

These râles are accompanied by a tone of genuine musical quality, very clear and of accurately determinable pitch. Frequently all the bubbles formed by the agitation of the fluid secretions have this ringing metallic character; in other cases only a few of them possess it, while the remainder are obscurely resonant; and in still another class of cases the râle, especially when it consists of but a few bubbles altogether, gives the impression as of drops of fluid falling from a height with a sound of acutely metallic intonation.

Râles of metallic timbre, especially single bubbles, may be best imitated by causing drops of water to fall some distance to the bottom of a metallic vessel.

Lænnec employed the term *metallic tinkling* to designate the phenomenon just described,—the intensely metallic sound of single bursting bubbles, simulating the dropping of water, occurring in large pulmonary excavations or in pneumothoracic cavities occupied by a certain quantity of fluid. It is certain, however, that the sound is exceedingly deceptive; it is not produced by the dropping of fluid, but, as above stated, by the explosion of single bubbles, whose tone is intensified by resonance in the cavity.

Râles of metallic timbre arise exclusively in cavities of considerable size, as large, at least, as the closed fist, which are enclosed by walls of uniform density, and are situated near the surface of the lung. These are precisely the conditions enumerated as necessary to the occurrence of the metallic percussion-sound and of the amphoric respiratory murmur. But the free communication which, in order to the development of amphoric respiration, must exist between the air of the cavity and that of the bronchus leading to it, and between the latter and that of the trachea, is not an indispensable condition in the case of the metallic râle; this is obvious from the fact that in the somewhat rare cases in which there is absolute closure of the bronchus opening into a large cavity,—as indicated by the total suppression of the respiratory murmur,—the ringing metallic râle may be at once elicited by sharp coughing, when the fluid and air in the excavation are thrown into violent agitation. The *metallic* râle has been justly explained as a true *phenomenon of consonance*, in contradistinction to the simply resonant râle, which owes its peculiar qualities to the better conduction of sound through solidified tissue. Amongst the many resonant bubbles which go to constitute it, but few have the pure *metallic* resonance; these are they whose pitch corresponds to the proper tone of the cavity, and for them the cavity acts as a resonance-chamber, in which the ringing quality of the râle is intensified (compare Bronchophony, p. 169). By using a suitable resonator, also, (see p. 95) the metallic sound may be greatly increased in intensity. It is often possible to recognise in the metallic râle several tones (fundamental tone and overtones) standing in harmonic relation to each other.

In those cases in which this râle is heard the respiratory murmur,—when not temporarily suppressed or rendered indeterminate by plugging of the principal bronchus, in which circumstances the metallic râle also is wanting during the respiratory act and is audible only on coughing,—is *amphoric* (accompanied by a metallic echo), so that amphoric respiration and metallic tinkling have come to be shortly designated metallic phenomena, or, as they occur almost exclusively in cavities, as *cavernous phenomena.*

The Sound of Succussion in Pyo-pneumothorax.

There remains for discussion a special variety of the metallic râle,—a *splashing*, accompanied by a ringing sound, heard in cases in which the *pleural sac is occupied by air and fluid* (pyo-pneumothorax), on shaking the patient while the ear is applied to his chest. This method of exploration was practised by Hippocrates,—hence the name by which it is generally known, *Hippocratic Succussion*. On shaking a jug partially filled with water a fair representation of this sign is obtained. In some cases it is very feeble, appreciable only by immediate auscultation or through the stethoscope, whilst in others it is audible even at a considerable distance.

In one patient who was under my care, suffering from pyo-pneumothorax on the left side, the splash could be heard in all parts of a large class-room, when he raised himself quickly on his toes and dropped back again on his heels.

When the cure of a pneumothorax is effected by the outpouring of a pleuritic exudation which, by its increase, gradually takes the place of the air, the sound of succussion is no longer appreciable. In encysted pyo-pneumothorax also, especially if it be of limited extent, the splash is wanting; and, further, it does not appear to be present even in every case in which the effusion is free and unconfined by adhesions, but only in those in which it is also of very fluid consistence (serous), and in that way easily thrown into commotion by shaking the patient.

The splashing succussion-sound *may* also be observed in *pulmonary vomicæ*, when they are of the *size of the closed fist* at least, and contain a very abundant and *thin* fluid secretion; but as the latter condition is exceedingly rare in phthisical and bronchiectatic cavities, it is only in very exceptional cases of this kind that the sound in question is heard. Gangrenous cavities do certainly contain a secretion of this character, but are seldom so large as to form a resonant chamber sufficiently spacious for the proper development of the splashing sound.

Dry Râles.

By this term are meant râles which do not create the impression of the bursting of bubbles or of liquid in motion, but which are comparable rather to the whirr of a revolving wheel, to the crisp noise produced by walking on frozen snow, to the crackling

of a dried bladder, &c. These comparisons come far short of exhausting the varied characters of the sounds under consideration; they cannot be regarded as minutely descriptive of them, but merely as expressive of some of their most striking and prominent resemblances. A little practice, however, will soon enable any one to distinguish readily between moist and dry râles. The transition from moist to dry sounds is gradual; the *creaking* and *crackling* sounds described on p. 156 may be taken as representing the forms intermediate between the two definite types, though they are almost entitled to be looked upon as dry râles.

The general diagnostic inference to be drawn from the presence of dry râles, with reference to the condition of the bronchi, is that *the mucous membrane is swollen*, and covered by a *scanty, exceedingly viscous secretion*.

From these dry râles is to be carefully distinguished still another class of sounds, in which there is no longer to be found any trace of the characteristic features of the râle; these are known as the *snoring, hissing*, and *whistling* sounds. As the sensory impression produced by them corresponds exactly to that indicated by the names they bear, (the sonorous rhonchus, for instance, resembling closely the deep tone of a bass string), their recognition presents no difficulty. These sounds are caused by the passage of the respiratory current of air through bronchi whose calibre is encroached-upon by swelling of the mucous membrane, or which are at parts temporarily obstructed by plugs of mucus. These conditions alone are enough to render the respiratory murmur loud and harsh, as may easily be shown experimentally by blowing through caoutchouc tubes which are compressed at certain points; but besides these causes the vibration of the prominent folds of the swollen mucous membrane and of the tough secretions adherent to them, take an important part in the production of the sounds. The *snoring sounds* (sonorous rhonchi) originate in the *large and medium-sized bronchi*, the *hissing* and *whistling* sounds (sibilant rhonchi) in the *small and smallest air-passages*. The former are low-pitched, the latter high; and this is exactly in accord with the teaching of physical science,—that the pitch of a tone, like that of a râle artificially produced in tubes, rises as the diameter of the chamber in which it is generated diminishes. These rhonchi

are very common in chest affections, and are most marked in acute and chronic bronchial catarrh,—both in the primary form and in that which results from the various diseased conditions of the pulmonary parenchyma, especially emphysema; they are generally audible over a large part of one or both sides, sometimes even over the whole, of the thorax, and vary in intensity with the degree of the swelling of the mucous membrane and the lumen of the bronchi attacked by the catarrhal process. The loudest are the sonorous rhonchi, occurring in the large bronchi. The character of the sounds depends on the size of the bronchi involved, being snoring or hissing and whistling according as it is chiefly the large or the small air-tubes that are affected; occasionally all three varieties are heard simultaneously, at the same or at different parts of the thorax. They are considerably louder than the moist râles, and are appreciable, even at a distance from the patient, in both inspiration and expiration, sometimes throughout the *whole* of the respiratory act, as sighing, moaning, or cooing sounds. As in these circumstances the elasticity of the lungs is diminished and expiration prolonged, the duration of the expiratory rhonchi is much longer than that of the inspiratory sounds. If the bronchi contain also a certain amount of fluid secretion moist râles are added to the dry sounds, and as fluid is found more frequently in the larger than in the smaller bronchi it is the sonorous rhonchus which is most often accompanied by râles (of the coarse or medium-sized bubbling variety), whilst the sibilant rhonchi are commonly free from such indications of the presence of liquids in the air-passages. The respiratory murmur is sometimes audible along with the sonorous or sibilant sounds; it is vesicular so long as the lung-substance remains permeable to air, or may disappear entirely, as in aggravated cases of pulmonary emphysema; it may be completely masked by the loudness of the dry râles, or may possess the characters only of indeterminate respiration.—All these dry sounds, which are shortly designated as *catarrhal*, may be modified by the assumption of the ringing, resonant quality, when the lung-substance at the affected part is completely consolidated; it is scarcely justifiable, however, to base the diagnosis of consolidation on this sign *alone*, as even while the lung is perfectly expansible these rhonchi show a greater tendency than any of the other râles to take on the character

referred to; this is clearly indicated in the names applied to them, sonorous, sibilant, &c. It is only necessary to auscultate a few cases of severe emphysema attended by dry catarrh, to become convinced of the frequent occurrence of this almost musical property of the dry catarrhal râles. They are all, especially the sonorous rhonchi, appreciable on the surface as palpable fremitus (see p. 68), but may also become unrecognisable, either by auscultation or palpation, for a longer or shorter period, or at least suffer considerable diminution in intensity, when the patient succeeds in expectorating some of the mucous secretions, which in these cases are always scanty and tenacious.

Several of the moist and dry râles, the special characters of which have been described, may co-exist in the same individual. Or the different orders of râles may assume the most diverse forms, merging into each other through multiform modifications, and that not only at different stages of the morbid process but within very short periods of time, in the space of a few minutes, for example, on coughing sharply. In the same way similar râles may be observed accompanying very different respiratory murmurs; thus with vesicular respiration all the râles, excepting the resonant and the metallic varieties, may be heard, with indeterminate respiration râles of every description, without exception, and with bronchial respiration râles of all kinds except the genuine uniform crepitation.

Pleuritic Friction-Sound.

This phenomenon presents to the ear much the same characters which are felt by the hand in Pleural Fremitus (p. 66). It gives the sensation sometimes as of the lightest rubbing, if stronger, that of shuffling, grating, or *creaking*, &c.; in the latter form, which is the most common, the sound is divided into several distinct portions of different intensity. It is sometimes audible only at the height of inspiration and the beginning of expiration, at other times, especially when breathing is vigorously carried on, throughout the whole of both phases of respiration. It is also generally, though not always, possible to form some preliminary conception of the intensity which the sound should present to auscultation from the distinctness of the thrilling sensation communicated to the hand. In some cases it is only its rougher, or more striking features that are thus perceptible to the sense of touch, whilst the ear takes in not merely these,

but also the fainter, less-marked indications; so that the signs of friction may persist much longer to auscultation than to palpation.—Occasionally pleuritic friction is so feeble as to be recognisable only by the ear, but absolutely inappreciable by palpation, particularly when it is exceedingly soft and not jerky or interrupted.

Very rough friction-sounds are accompanied by fremitus so easily detected and of so marked a character that to mistake them for any of the other chest-sounds giving rise to vibration which may be felt by the hand,—such as the *râles* of diffuse bronchial catarrh (see p. 69),—is scarcely possible. And it is only with râles *perceptible to touch* that friction-sounds are likely to be confounded, as the very general palpability of the latter constitutes a perfect diagnostic distinction between them and the non-tangible râles. That confusion should arise is scarcely conceivable, except in those cases in which the friction-signs are either so exceedingly weak as to escape detection by the finger, when the diagnosis must be made by means of auscultation alone, or in the rare instances in which fremitus due to the presence of râles occupies a space as *circumscribed* as that of the friction-sound, though even here simple palpation suffices, as a rule, to establish the distinction (see p. 69); or, finally, when friction-sounds and râles co-exist side by side. In all these cases, however, the diagnosis can easily be made by auscultation. *To auscultation râles and friction-sounds are distinguished from each other* by the following points: *the former* make on the ear the impression either of the *bursting of bubbles*, or of rough snoring, whistling, hissing, *dry* sounds, and *undergo various modifications on coughing*, particularly with respect to the loudness, number, and size of the bubbles; *the latter*, on the contrary, show no trace of the acoustic properties expressed in the words *moistness* and *dryness*, while they are also absolutely uninfluenced by coughing. Friction-sounds, further, are not uncommonly intensified by the pressure of the stethoscope, as in this way the opposed surfaces of the pleura are brought into closer contact, and the friction increased at the part under examination; râles, on the other hand, are not affected by this manœuvre.

Friction-sounds may be *associated* with the most diverse varieties of *dry or moist râles*, when the pleurisy is combined with diffuse bronchial catarrh. They may be heard accompanying the respiratory murmur, or the latter may be completely hidden by the loudness of the rubbing; or the bronchial catarrh which so generally attends pleurisy may render the vesicular respiratory murmur so loud and harsh that friction-sounds existing in the same part of the chest, provided they are only of the rubbing or shuffling, not of the creaking character, are heard with extreme difficulty. In these and similar cases the question as to the possible *association* of friction-sounds with râles may be most readily settled by repeated auscultation, especially when this is supplemented by a consideration of the phenomena produced by coughing and by superficial and deep respiration.

Pleuritic friction in the neighbourhood of the heart is apt to be mistaken for pericardial friction. But suspending the respiration distinguishes between them at once: pericardial friction remains, pleuritic friction disappears.

The pleuritic friction-sound is rarely heard at the beginning of an attack of pleurisy, as the inflammatory products seldom have, at that stage, the requisite degree of roughness, and the patient, also, is constrained to breathe very superficially, on account of the acuteness of the pain. In the succeeding stage of the disorder likewise, when effusion has taken place, there is no sound, as the roughened pleural surfaces are separated by the fluid. It is usually first observed when the process of absorption of the effusion begins, and the more rapidly this progresses the greater the number of points at which the sound becomes audible. It is not present, however, in every case of pleurisy, as the exudation is not invariably fibrinous, but is occasionally simply serous. Pleuritic friction is always wanting, therefore, in cases of *transudation* of fluid into the pleural cavity. The sound, further, is sometimes heard in pleurisy without effusion (*pleuritis sicca*), but only in circumscribed spots, usually those which the patient complains of as painful; it is then also usually of the light rubbing or shuffling character.

When the friction-sound is absent in such cases the diagnosis of circumscribed pleurisy rests, so far as anamnestic symptoms are concerned, on the occurrence of localized pain, increased in deep inspiration or on exercising pressure on the spot in question.

But circumscribed friction occasionally arises from quite other causes: it may depend on fractures of the ribs, when the sound is produced, not merely by means of the fingers, by rubbing the fragments on each other, but also by the movements of respiration; or on certain morbid conditions, affecting primarily the osseous or cartilaginous portions of the ribs, and subsequently involving the adjoining part of the costal pleura, causing the deposition of inflammatory products upon it.—Inequalities of the surface of the visceral pleura, a somewhat rare condition, may also generate friction-sounds. A case of this nature, occurring in a patient suffering from acute miliary tubercle, is recorded by Jürgensen; the friction arose, as was seen on post mortem examination, from the constant rubbing of the smooth costal pleura on the surface of the lung, which was closely studded with numerous little prominent tubercles. And even during the patient's life the sound, which was soft and widely distributed over the chest, perceptible both to the hand and to the ear, gave the impression of rubbing against a surface covered by a multitude of small excrescences.

Auscultation of the Cough.

The cough of the patient is sometimes made use of as an aid to auscultation, but in many cases is also itself made the subject of direct examination.

As an adjuvant to auscultation it answers many purposes:

1. After repeated coughing inspiration becomes deeper and the respiratory murmur louder.

2. Casual obstruction of the bronchi by plugs of mucus is removed by coughing, especially if followed by expectoration; communication between the air-passages and the substance of the lung is thus re-established, and the respiratory murmur, previously suppressed or indeterminate in character, becomes clearer. The nature of the respiration after coughing depends on the state of the lung itself, being bronchial in consolidation or excavation of its substance, vesicular if it be still of spongy texture.

3. Râles are often first called into existence, or are considerably intensified, by coughing; it agitates the fluids which are lodged in the pulmonary vomicæ and in the bronchi, throwing them into more violent commotion than ordinary respiration; it frequently also has the effect of collecting and driving the secretions into more confined spaces, and thus of increasing the number and intensity of the râles. During the cough, therefore, and in the deep inspirations following it, the râles are heard with great distinctness. Occasionally, however, the râles, notwithstanding the complete absence of expectoration, become weaker at certain parts after coughing, and stronger at others; this is plainly due to the shifting of the liquids in the air-passages.—These changes in the râles, as the result of coughing, are observed with great frequency in diffuse bronchial catarrh.

4. The ringing character of the metallic râle is generally brought out by coughing, if it is not already observable in ordinary respiration.

The cough itself is auscultated, as it developes certain peculiar acoustic phenomena in consolidated lung-tissue and in cavities: it becomes exceedingly loud in solidified lung, louder, at least, than in lung which is permeable to air, and in large superficial cavities it further acquires a distinct *metallic ring*. Auscultation of the cough alone, therefore, is sufficient to decide whether the

subjacent part of the lung is solid, of spongy texture, or hollowed out into cavities.

The cause of the greater distinctness of the cough over condensed tissue and excavations lies in the superior sound-conducting power of indurated lung-substance.

It remains now to discuss *the cough as a symptom* in diseases of the respiratory organs and *its signification from a diagnostic point of view*.

Cough is produced by the sudden and forcible opening of the glottis by the expiratory current of air. It is frequently an entirely voluntary action; at other times it occurs independently of the will, as a *reflex* action, when the terminations of the sensory nerves in any part of the mucous membrane lining the air-passages, from the larynx down to the smallest bronchioles, are subjected to any abnormal irritation. The most sensitive part of the mucous membrane is that which protects the larynx (especially the inter-arytenoid region) and the trachea as far downwards as its bifurcation; coughing may at any time be artificially excited in animals by irritating any part of this portion of the membrane (Nothnagel, Kohts). The mucous lining of the bronchi is much less sensitive. These views find ample corroboration in certain pathological observations; thus it commonly happens that most violent coughing is set up on the intrusion of foreign bodies into the larynx, and that, further, if the efforts made to expel these bodies be unsuccessful, if they rather sink deeper into the bronchi, the coughing becomes less distressing and may finally entirely cease.—Irritation of the costal pleura, also, provokes coughing, while stimulation of the visceral portion is powerless to produce this effect, as has been shown by experiments on animals and some observations in the human subject. Whether coughing may be brought on, by reflex action, from irritation in the stomach, is still doubtful, though some of the phenomena met with in disease seem to point in that direction; it has never yet been accomplished experimentally.—Stimulation of the vagus in the neck, of the superior laryngeal nerve, and of the nerve-centres from which the constituent fibres of the vagus spring, induces attacks of coughing (Kohts); in those cases, therefore, in which coughing appears as a symptom accompanying some disease of the nervous system, and apart from the existence of any concurrent pulmonary disorder,—as in some instances of hysteria,—it may be referred to an abnormal condition of irritation in the course of the vagus. Further evidence of such a purely neurotic origin is found in the fact that the cough usually comes on in paroxysms, like that of tussis convulsiva.—Most attacks of coughing are preceded by a *tickling* sensation in the larynx, even when the affection which excites them is not located at that point, but in the bronchi. This tickling forces on the cough, or at least makes it difficult to refrain from endeavouring to find relief in that fashion.

The irritation necessary to the provocation of coughing, apart from