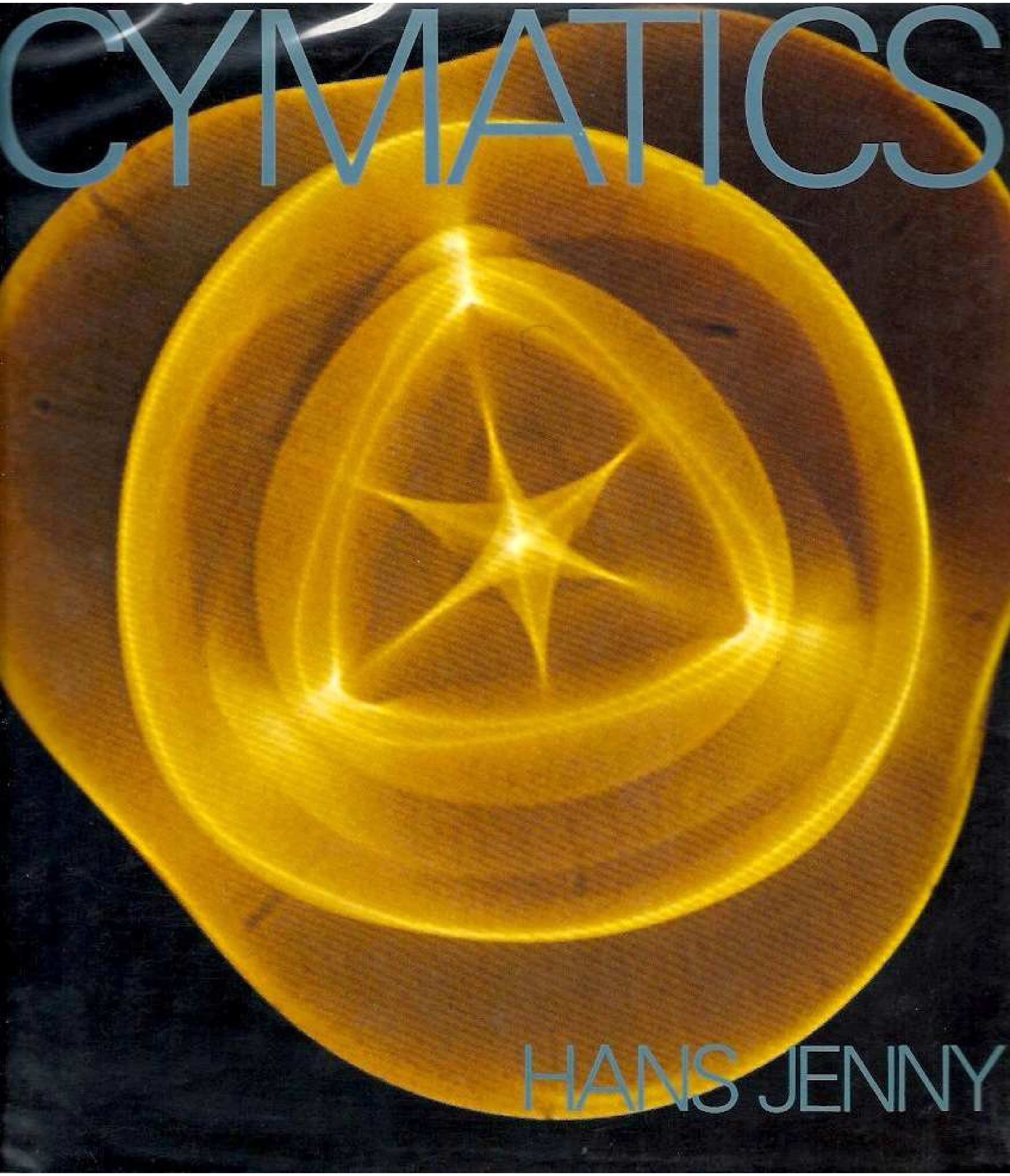
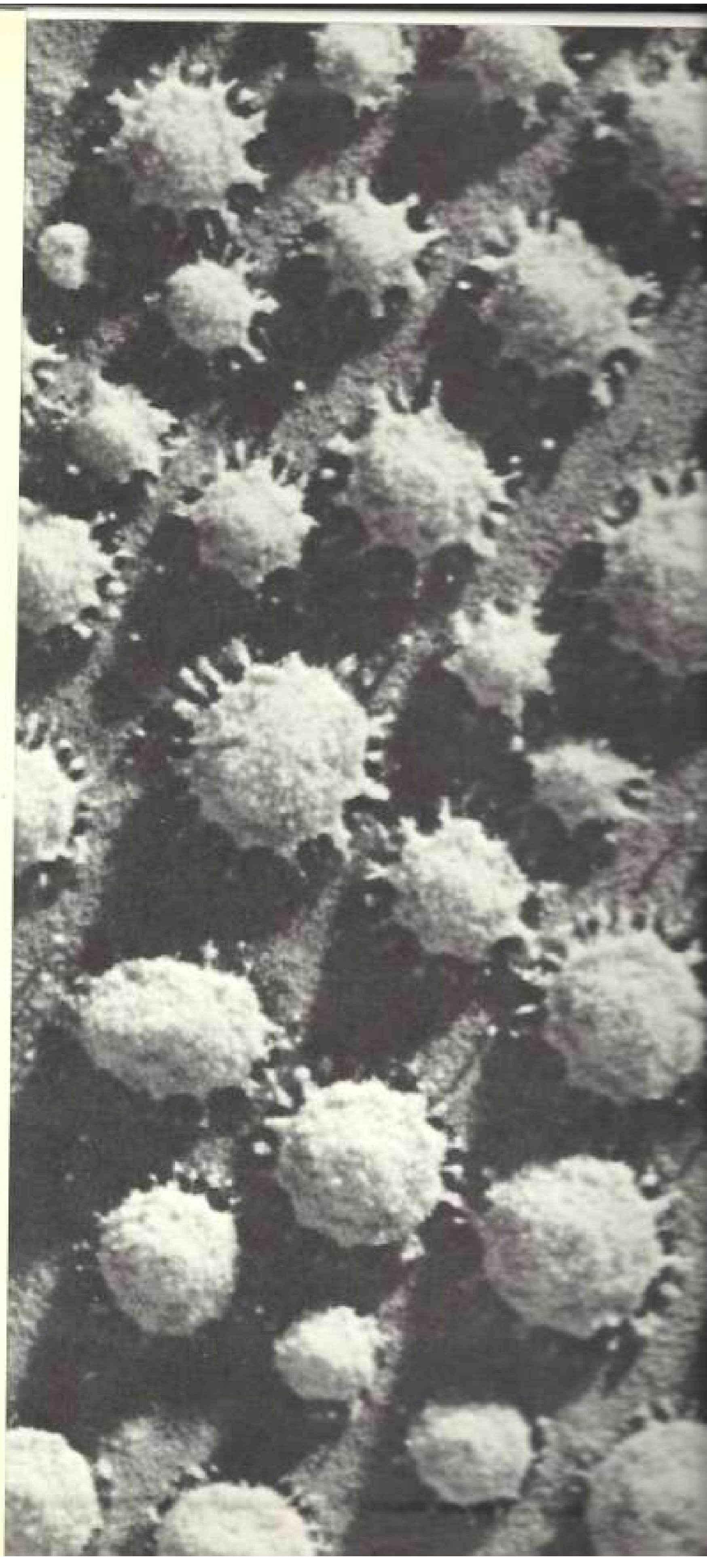

CYMATICS
HANS JENNY

CYMATICS [Volume 2]

To visualize the world of wave phenomena and vibrations in all its remarkable diversity, a number of systems are subjected to the action of vibration. If the phenomenon thus produced is examined in its entirety, visual models can be clearly defined, and, stage by stage, the various aspects of a vibrational system made manifest. Numerical and symmetrical relationships can be demonstrated and disclose harmonic vibrations which conform strictly to laws in their structure, dynamics and pulsation. What is in effect a harmonic proto-phenomenon becomes visible in terms of pattern, movement and periodicity as a complex but unitary whole.
In this way conceptual models are obtained which research can apply when investigating vibrational systems, for, if vibrations are an essential feature of a field, then this field must contain cymatic effects. Thus armed, the eye of the investigator can interrogate such areas as geophysics, astrophysics, and above all the numerically ordered and symmetrical world of animals and plants, and seek fresh insights there.
An investigation of the world in terms of cymatics throws an interesting historical light on earlier philosophies resting upon mathematical order and the relationship of sounds, musical tones and words (Heraclitus, Pythagoras, Archytas, Plato, Aristoxenos, down to Kepler and many others). Connections are revealed between such philosophies and the knowledge of cymatic phenomena independently acquired through modern scientific research.

German edition



KYMATIK

HANS JENNY

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HANS JENNY

CYMATICS

WAVE PHENOMENA
VIBRATIONAL EFFECTS
HARMONIC OSCILLATIONS
WITH THEIR STRUCTURE,
KINETICS AND DYNAMICS

VOL. 2

HANS JENNY

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Contents

Dedicated to the memory and research of Rudolf Steiner

Cymatics

What effects do vibrations produce in a concrete medium? What effects appear in a system and its environment when wave phenomena are inherent in that system? An answer to these questions was sought first of all in the acoustic field, where experiments revealed a characteristic phenomenology of vibrational effects and wave phenomena with typical structural patterns and dynamics (cymatics). Serial phenomena of this kind were presented in our first volume (Cymatics 1967). These studies are continued in this second volume.

Here again methods have been employed in which the phenomenon is treated as a whole and not anatomized. Why is this? When we observe a phenomenon, it is natural to concentrate on one single factor and make it the focus of our attention. Now, if such a factor is abstracted from its context and allowed to dictate our procedure, the investigation tends to become biassed and other characteristics of the object under study are easily missed. This is clearly reflected in the history of science in the way interest has alternated between opposed theories. Of course, certain special characteristics of things do at first appear more conspicuously than others in the field of vision. Nor is it possible initially to do other than single out by analysis the various aspects of the phenomenon under observation. Even so, the attempt must be made to return time and again to the original phenomenon and time and again to look at it with fresh eyes.

For instance a system may contain structural patterns which are quite overlooked because the observer is concentrating on dynamic processes, but which show up when, as it were, he takes a fresh look at its features. It may be objected that with this method the end is never reached, that there is always something which may elude observation, and that there is no way of knowing whether one "has seen everything". It is a fact that research opens up one new vista after another and that natural science is a "never-ending business" (Goethe). It follows, then, that the investigator must remain continually alert within the field of observation. By failing to do so, he loses touch with reality and forfeits his chance of attaining the "really real". It is characteristic of this ultimate reality that the most diverse processes should be manifested in one and the same phenomenon: pulsation, circulation, pattern formation, changes of phase, etc. Between all these there is an intimate connection. Were one of these processes to be suppressed or eliminated, the phenomenon would cease to be. What we have, then, is something of a unitary nature, something like a necessary connection between such diverse processes. Here we may be said to have a

"whole", something that must be conceived and understood as a totality. The individual aspects of the phenomenon cannot be regarded as being self-existent. One must speak of totality and of a total phenomenon. Any attempt, however, to lay hold of this wholeness in conceptual terms raises epistemological difficulties. And, indeed, attempts to define "the whole", "the totality" often lead to abstractions which are incapable of comprehending the whole living phenomenon and, as it were, allowing it to take shape in the cognitive mind. What, then, is to be done? The answer is we must make bold use of our judgment based on concrete vision (Goethe). This brings us to a form of cognition which analyses *and* synthesizes, separates *and* unites, establishes categories, notes their correlations, follows their appearance and disappearance, discovers their unity in diversity, and, at the same time, continuously keeps watch on itself, remains accountable to itself, and constantly asks itself: is it you or the object that is expressed here (Goethe)? The process of comprehending the phenomenon as a whole calls for such a methodology. What this research really involves, then, is a method, a way – and, what is more, a way which must always first constitute itself.
The position, then, of empirical observation is a special one. It asks questions, as it were, of the object. Changes can be rung on these questions. One condition or another may be stressed. An interplay between the various factors comes to light. Phenomenological categories are revealed: the phenomenon acquires characteristics in time and space, assumes quantitative and qualitative features, becomes defined as material, as structure, or as movement, reveals its origins, becomes individualized in its transformations, metamorphoses and self-integrations, in the centering of its polarities, in its disposition, in terms of its numbers and symmetries, and in its intensifications; it appears as entelechy (as uninterrupted activity and effect), as the configuring and the configured, as entity, as individuation, as essence, etc. And through such definitions and conceptual operations runs cognitive sentience and sentient cognition.
A very special feature of the study of vibrations is the way in which the observer penetrates to the genetic element. Before our eyes we have the creative and the created, the vibrating and the sounding, and also what is produced by vibration and sound. Now none of this can be simply and harmlessly dissected out for examination. The events of the wave sequence transpire under complex conditions, in interferences, resonances, turbulences, in harmony, consonance, in disharmony, in dissonance, in frequency spectra, amplitude relations, etc. It is

in this sphere of multiple creation that the investigator must carry out his observations. He must find out whether amidst all this tumultuous activity there are basic or ultimate phenomena in terms of which "everything else" can be comprehended. It happens often enough that we have the parts in our hands but unfortunately lack the "mental ribbon" (Goethe) with which to bind them together. What is the status of the parts, the details, the single pieces, the fragments? In the vibrational field it can be shown that every part is, in the true sense, implicated in the whole. If we single out of a detail, if we follow an individual part, it will be found on careful observation that the sum total of connections, albeit specifically transformed, is reflected in it. Or, vice versa, remove the part, its properties, the fact of its existence, and the whole will cease to be. So the whole is inherent in the part; the part exists in the whole in a special way; the multiplicity which we perceive as parts is at the same time the multiplicity of the whole. The whole is always present in its totality; the part, if we scrutinize it properly, reveals itself to be the whole. These general propositions must be verified in the course of our documentation.
One may object that it is not possible to talk in such simple terms of the "whole" since there is no general agreement that what we have in front of us actually represents the whole; research may have failed to identify some essential constituent which still remains hidden. It is perfectly true, of course, that we are confronted by the largely unexplored. But what we have observed and comprehended is, under the conditions we recognize, stamped clearly enough with the character of totality. Something with the features of wholeness is to be seen "in the plan and elevation". Research draws closer to totality by successive approximations; that is the way research proceeds. The objection ceases to be valid, then, if the truth of what has previously been posited is substantiated, namely, that the whole is present in the so-called part, transformed and particularized perhaps, but nevertheless reflecting the totality in all ist basic functions. The further we delve into cymatic effects, the more apparent these relations become to us. Let us take a look at biology in this context. If we remove all

* This aphoristic remark on the living cell is intended to imply that in the individual living cell *all* basic functions are present (respiration, metabolism, mitosis, plasticity, metamorphic potentially, regulative processes, controls, sentient capabilities, contact potentialities, outside/inside relationships, correlations, etc.) Remove these processes, and life is nor more. So the "whole of life" is present in the individual cell. If everything contained in the cell is known, then the whole of life is known.

the properties displayed by a living cell, if we do away with everything affecting this "part", all organic life is extinguished*. Now it might be said that all we have to do is simply to observe the parts, that it is quite unnecessary to concern ourselves about the whole; if the parts are already the whole, then they provide us with an appropriate object through which to attain to the whole. This would be true if we had the power of truly comprehensive observation; but this is exactly what must first be acquired. And observation of the real, immediate phenomenon is the best and most reliable way of acquiring it. For one aspect of the phenomenon points to the other, and in this way one gradually comes to grasp how the whole is inherent in the part. If our propositions concerning the part as a whole can be verified, they also imply an epistemological factor since the cognitive organs from which knowledge is derived are a part of the human organism. Now if such a part contains the whole, one may suppose that in this part, namely in the brain as the instrument of cognition, *the whole* can appear in its specific sphere in an ideational form – as thought. In thinking, then, the whole will be capable of manifestation in terms of thought. Thus we see that man is able to excogitate a phenomenology of the galaxies, quasars, pulsars, or of atomic nuclei, or of molecular biology, etc. How could we speak of such things at all if our cognitive faculties were incapable of approaching and comprehending the whole through the processes of thought.

To enable the reader to enter into the spirit of cymatic phenomenology, we shall first of all present some additional sets of experiments in this second volume, beginning with a simple exposition of certain phenomena. These will afford some idea of the great multiplicity of vibrational phenomena. At the same time the reader will be gradually introduced to the complex nature of periodic sequences. The phenomena occurring in capillary interspaces under the action of fibration convey some notion of the richness and diversity with which wave phenomena are manifested. Again, remarkable formations are obtained if ferromagnetic substances are exposed to cymatic influences in a magnetic field. The forces of adhesion and cohesion are reduced by vibration and the masses can flow plastically, giving rise to curious configurations.

The additional documentation presents symmetrical phenomena exhibiting features of number and regularity which can also be demonstrated in space. To throw light on these characteristic numbers and symmetries we investigate the vibrations of the electron beam and the mechanical pendulum. Observations are also made of harmonic phenomena in fluids. Here mathematical arrangement and symmetry are observable throughout the phenomenon, its structure, its dynamics and pulsation. An attempt will be made to explain these harmonic processes, which occur in all categories.

With this cymatic phenomenology for reference, we can turn our attention to other fields of natural science on the principle that, if vibrations are among their essential constituents, they will also exhibit cymatic effects. This will be illustrated by reference to certain examples. Above all, however, we shall be dealing with the problems raised by symmetry and mathematical arrangements in organisms. Out of these questions a real research programme has taken shape. The relations between analogy and homology must be discussed.

Since really perfect harmonic relationships appear to the observer in terms of sound and intervals, anyone interested in history will wish to look at earlier philosophies which were largely modelled on number order, symmetry, and harmony in the cosmos. A few connecting points with such world pictures are intimated.

The book closes with mention of some additional aspects of cymatics and a glance ahead at the continuation of the experiments. It must be realized that the observations represented here are only, as it were, stages on our journey of exploration into cymatics. The action of acoustic vibrations has been traced, specifically the effects of tone, musical sound, and speech sound. These observations must be extended by investigating the continuous series of phenomena associated with tones, speech sounds, and musical sounds. We have, of course, visualized, photographed and filmed sequences of tones and speech sounds, and recorded the vibrational effects produced by music. But the real work on what might be called *melos*, or speech, is still to be done. This brings the larynx and its action into the scope of our studies. And at the same time we are confronted with the origination of vibrational effects, the generative element; we must learn about the larynx as a creative organ which displays a kind of omnipotent nature in its field.

In this second volume we have once more deliberately dispensed with descriptions of experimental design and particularly of the quantitative analysis of parameters. We have been primarily concerned with bringing the phenomenon into the field of observation. It is of secondary importance at this juncture how we excite the diaphragms, plates, films, etc., whether we use schlieren or photo-elastic methods, and whether we use mechanical or piezo-electric means of producing vibration. The phenomena of vibrational effects and waves can be visualized in a large variety of ways. Indeed, most of the phenomena recorded can be produced directly by the human voice in the tonoscope without recourse to electroacoustics. What is of prime importance is that the peculiar spectrum of cymatics – made up of patterns and figures on the one hand and dynamics and kinetics on the other – should be witnessed and recognized in its uniformity and totality, that the eye should be alerted to interpret the true nature of periodicities and rhythmicities, and that the features of cymatics should be discerned in the various fields of knowledge in the form and manner peculiar to any specific one of them. First and foremost, then, it is a question of developing a special sense for perceiving and observing rhythmic and periodic systems. Again it is our concern in this second volume to train this ability and it is hoped that this documented excursion into the field of cymatics will serve this end.

The wave lattice as a configuring field

The wave lattice generated in a liquid by the action of sound (Fig.1) imposes a spatial pattern on a diffusion process occurring there. Into the vibrating liquid we drip some of the same liquid which has been coloured with a marker dye, expecting that we shall see it mix intimately with the outspread film. However, instead of diffusing uniformly, the coloured liquid first shoots, as it were, in jets through the meshes of the lattice. If we greatly intensify the process, say, by turning up the volume of the tone (increase of amplitude), we see how the coloured liquid jets forth but always in a particular direction. If we examine one of these jets more closely (Fig. 2), we can see that the liquid moves through the lattice in a complicated manner. While the main jet winds along its course, there are suggestions of lateral branches with a curious rotary formation. The liquid appears to be streaming through the pattern in vortices. Gradually a homogeneous distribution is achieved by diffusion. This apparently unremarkable process is singled out for particular mention because it shows how, in this simple experiment, observation is guided forward step by step by the phenomenon itself. We might note that structural patterns generated in a particular medium by vibration do in actual fact exercise a spatially directive function and, having described the facts of the matter, leave it at that. But, if we leave it simply at that, there is basically a great deal which remains unexplained. First we speak in general terms of a wave lattice, and then of a jet-like vortical movement, and so on. Now, we have taken just such an elementary experiment as this to show that, by looking further, we can make some entirely new discoveries; for when we reach the chapter on harmonic vibrations, we shall refer back to this experiment (Figs. 1 and 2) and be able to see and appreciate everything that happens in the liquids there, indeed everything that is transpiring in the "simple" wave lattice before we add the drops, the structural and circulatory conditions in which the drops are involved on being added, etc. Let us take this experiment as an example of how observation is tutored by the phenomenon itself, how in this instance our eye is caught by the curious lateral formations of the diffusing jet and we are induced to investigate the matter further by, say, the schlieren method to ascertain exactly what is happening. As we have said, we shall return to this experiment when we have obtained a wider view of the subject as a whole.

1, 2
The wave lattice generated by vibration guides the liquid diffusing there (dark areas) in a particular direction. Within its "meshes" it functions as a true structure. (Natural size.)

2 (Detail)
Shows in addition curious "lateral branches", which can be investigated by schlieren methods (see chapter: Harmonic vibrations, p. 95).

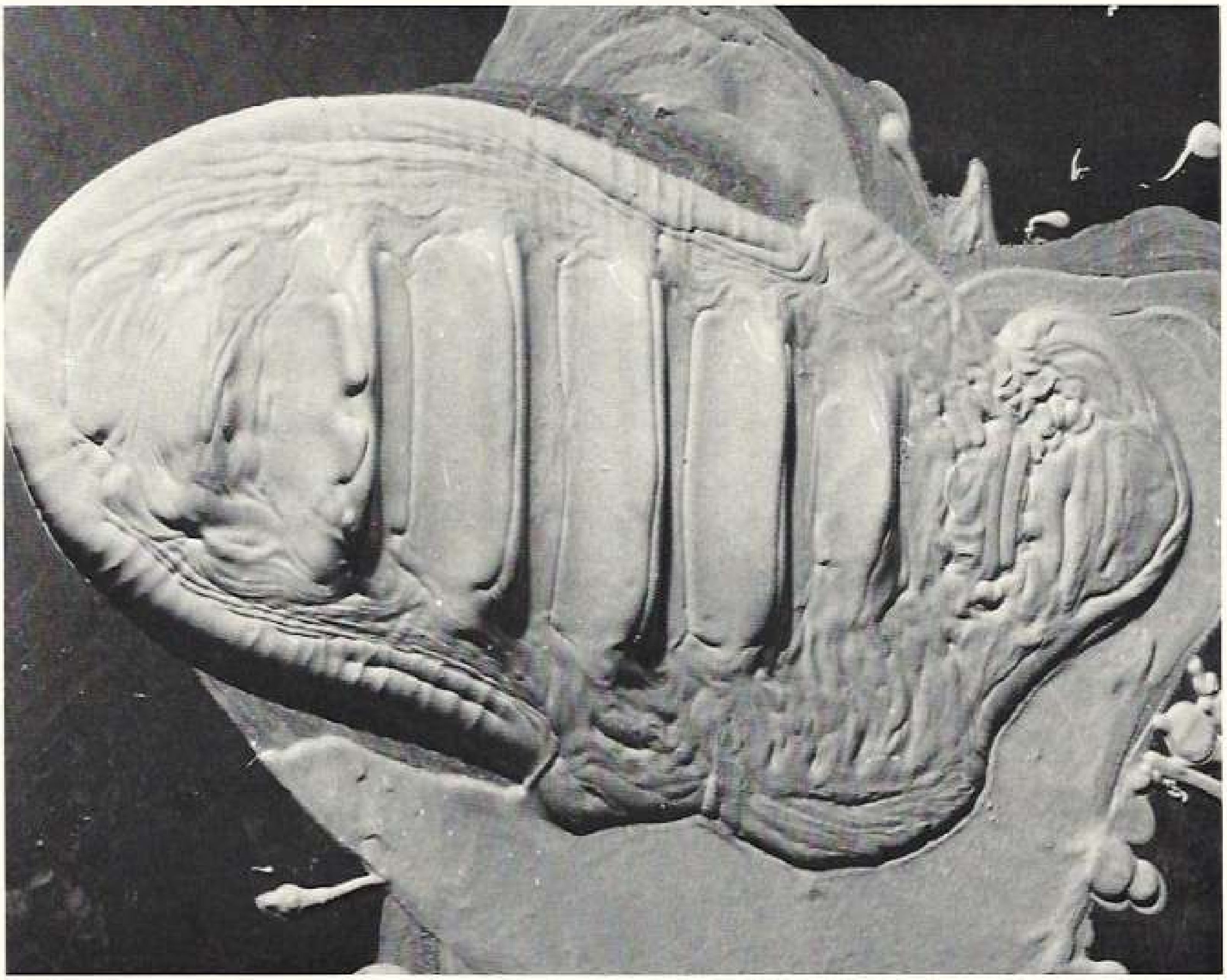
1

2

Circulation in the wave train

If waves are generated in a viscous paste by vibrations, a strange phenomenon appears under suitable experimental conditions. At first the mass is seen to be rising and falling in waves. Then curious furrows appear which are particularly prominent in the wavecrest phase. The paste seems to be disappearing down these fissures. But where is it going? If a spot, say, on the side of the crest, is marked with a stain, it can be seen rising towards the furrow, and then actually disappearing down it, only to roll round and reappear again immediately at the side. By using the stroboscope (an instrument enabling rapid movements to be seen in slow motion) the process can be followed in detail. In Figs. 3 and 4 the paste is arranged in waves. The furrows we have described are visible on the crests. The waves must be imagined to be rising and falling while *at the same time* the entire mass of paste is flowing symmetrically and bilaterally into the furrows, and then rolling up again only to disappear down the furrows once more. In other words circulation and undulation are combined. What is so striking about the spectacle, however, is the elegant way in which the whole process conforms to a uniform pattern. Each of the two processes, well defined in itself, follows an orderly and regular course without giving rise to turbulence.

If one can imagine oneself, so to speak, transposed into the vibrating mass, one would experience the rolling and the up-and-down movement of the waves as *one* single self-contained process. At the same time there would be a symmetrical movement due to bilateral circulation. It goes without saying that the components can be separated, and the wave process and the circulation visualized apart by a suitable arrangement of the mass. And, indeed, this is necessary if the conditions are to be elucidated. What appeals to the imagination so strongly, however, is the simultaneous and orderly interplay of the two processes of undulation and circulation. At the same time it must be remembered that the phenomenon is generated by a *single* tone. This example brings the complex nature of vibrating media sharply into focus. It also encourages the observer to probe further because, besides undulating and revolving bilaterally, the mass is also pulsating. What our minds conceive as separate aspects is performed by Nature as a uniform process; the cymatic effects of pulsation, undulation and bilateral circulation in the viscous mass merge into a whole.



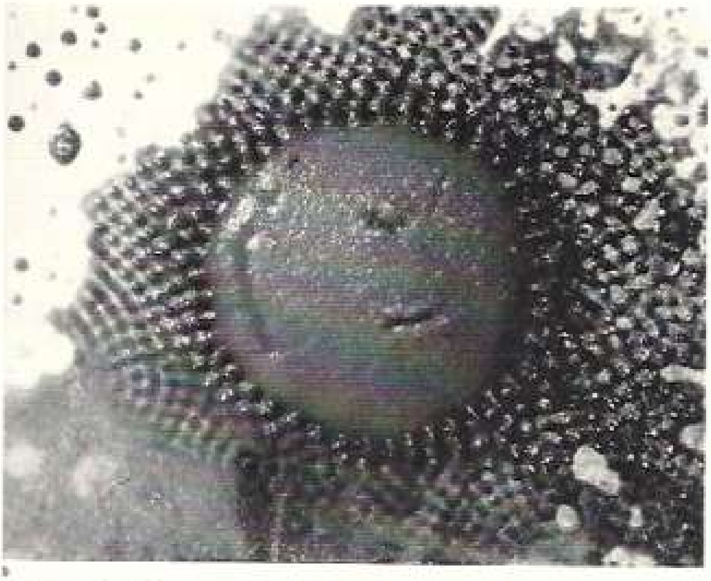
3

3, 4
Waves generated by vibration in a viscous paste: on the crests of the waves there are furrows into which the substance pours in such a way as to start a rolling motion. This circulation is bilaterally symmetrical and can be made visible by using a marker dye. The processes of undulation and circulation are not merely simultaneous but also unified. The impression created is one of unity. (Approx. natural size.)

4

Changes of phase in matter at the same frequency and the same amplitude

The next of the experiments introducing us to the richness of the world of cymatics shows how the properties of a medium change under the influence of vibration. For this purpose we use a mixture of salt and water which we excite by vibration. A typical and commonly seen effect is that the mass forms into a ball. In Fig. 5 the mass is shaped like the cap of a sphere. Round about can be seen the wave pattern impressed by vibration. The mixture is pushed together by the conglobing forces and at the same time the water is expressed from the brine. This brings about a change in the consistency of the medium. Fissures appear and the material breaks up (Figs. 6, 7, 8). The fragments are ejected and scattered. The scene is now one of total ruin (Fig. 9). The ejected fragments remain in the field of vibration, recover their flowability in the expressed water (Fig. 10), congregate again under the vibration to form the cap-like shape (Fig. 11), and once more build up into the regular round hillock (Fig. 6) only to repeat the process of change, disintegration and, again, restoration. The cycle goes on repeating itself regularly. Thus we have the curious spectacle of the material undergoing wholesale changes while the exciting tone remains the same and does not even alter its volume. What we see is a cycle of contrasting phases at the same frequency and amplitude. This experiment shows, then, that one and the same uninterrupted vibratory impulse is capable of sustaining cyclical changes of phase.



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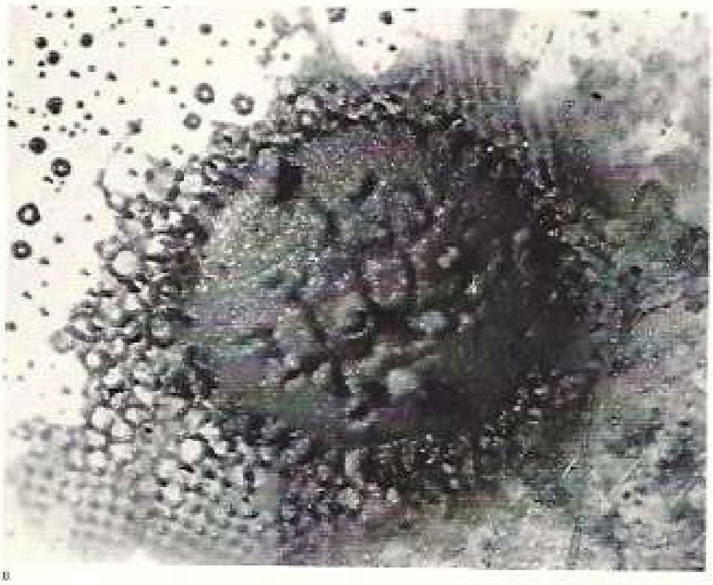

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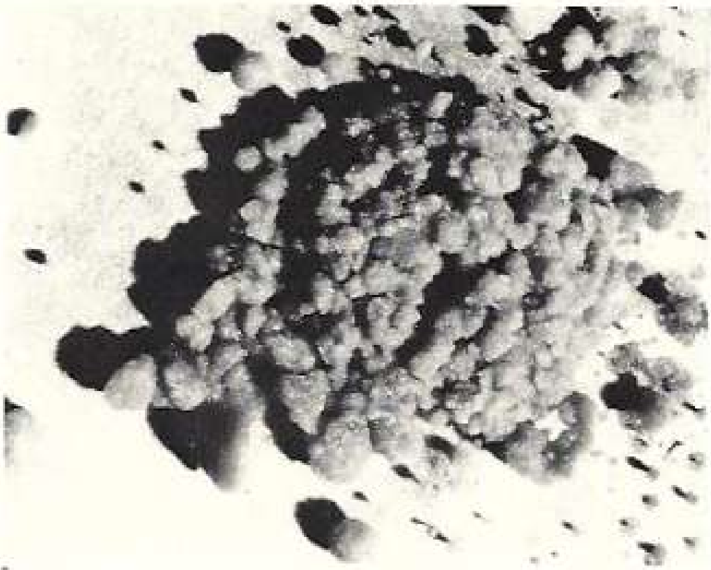
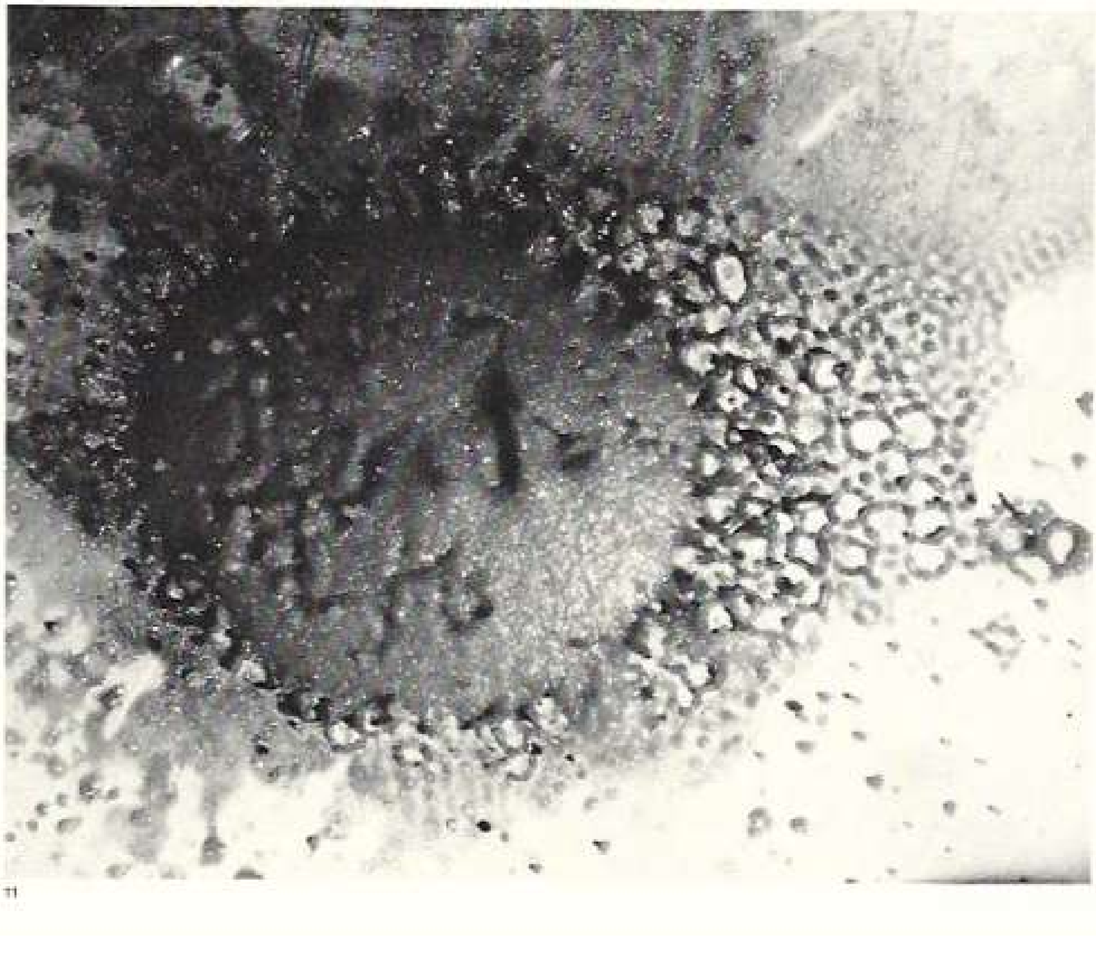


8

9

5, 6, 7, 8, 9, 10, 11
Vibration causes a mixture of salt and water to clump together into a circular shape (Fig. 5). More and more water is squeezed out by the clumping process and the brine changes in consistency. The mass begins to break up into bits (Figs. 6, 7) which are ejected (Figs. 8, 9) but then recover their flow properties in the vibrating water. The circular pile forms again (Fig. 11) and the pattern of the initial stage (Fig. 5) returns. What we have therefore is a cyclical process which is sustained while the frequency and amplitude remain unchanged. Although Figs. 6 and 11 are similar in appearance they actually show opposed phases of the process; in Fig. 6 the process leads to disintegration, in Fig. 11 to the formation of a uniform ball. (Fig. 11 natural size.)

10

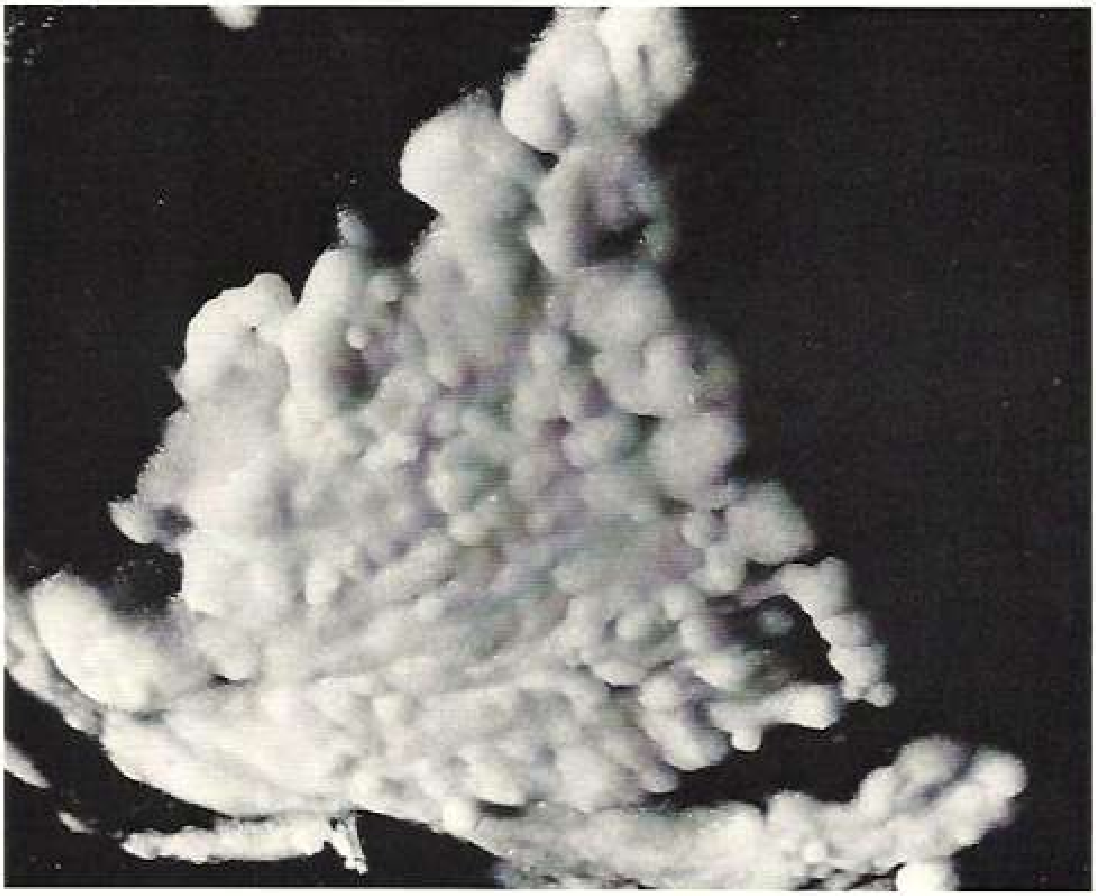


11

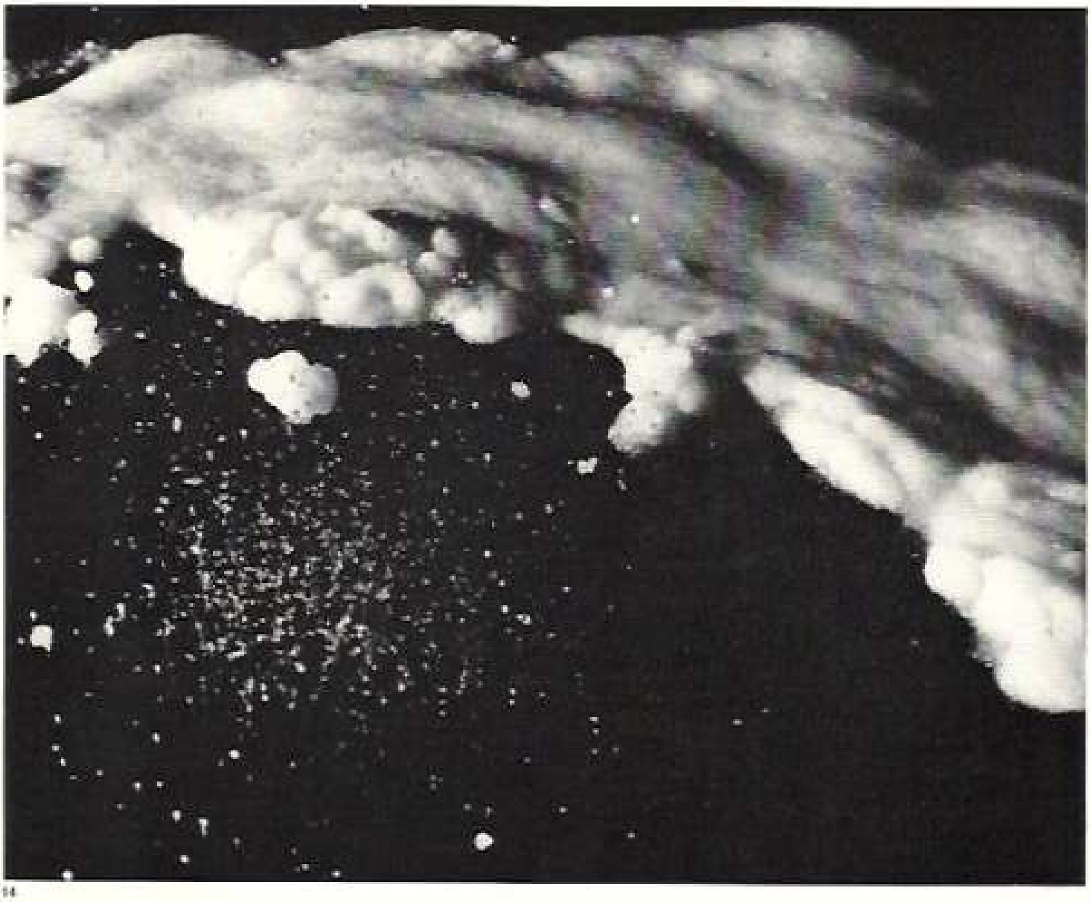
The influence of vibration on flowable and solid substances

In the following experiments flowable and solid substances are subjected to vibration. These experiments are comparatively simple, yet the phenomena are of extraordinary complexity. We shall try to describe a number of these processes with the aid of photographs. It is, of course, hardly possible to evoke the impression created by the original process. Like all the other phenomena illustrated in this book, these have also been filmed, for the motion picture is a record of the process whereas still photography perpetuates the structural pattern as additional documentation.

First of all the substance is spread uniformly on the diaphragm. As soon as the tone starts, the whole mass comes to life. A relief pattern of hill-like waves appears (Fig. 12). But at the same time the substance is set in motion and conforms to the topographical features of the vibrational field, and all the time this is happening the movements of both the substance and of the diaphragm can be followed in detail with the stroboscope. The layer of substance changes, growing thinner at certain points and piling up at others. At the same time these various regions begin to creep round. Fig. 13 shows the substance flowing along in this way, shaping itself into a cumulus-like configuration as it goes. In Figs. 14 and 15 marginal areas come into view. This whole "coast line" with its undulations, bays and promontories, etc. is caused by vibration. It frequently happens that the layers thin out as the process continues and then immediately clump together again. The processes have a pronounced tendency to repeat themselves. The way the individual "floes" move round is determined by vibration. If at the same time the vibrating diaphragm is tilted, the masses slide along very easily because vibration reduces adhesion to the substrate. And then, apart from the effects on adhesion, the power of the substance to cling together is also diminished by vibration, and this reduced cohesion causes, as it were, the material to become more fluid. These two effects of vibration – reduced adhesion and reduced cohesion – play a crucial role throughout. It should also be noted that the vibrational field is so strongly impressed on the mass that in certain zones the material can be clumped and held against the inclined plane of the diaphragm. At such points it may even move contrary to the force of gravity. (This antigravitational effect of vibration is described in "Cymatics 67" in greater detail). These movements, then, constitute a complex process: with the diaphragm flat they are caused solely by the vibration in conjunction with reduced adhesion and cohesion; with a tilted diaphragm there is interplay between gravitational forces and the effects of vibration. Thus the masses slide around,



12, 13, 14, 15
A flowable mass assumes a characteristic pattern under the influence of a high-frequency tone. Trains of waves take shape (Fig. 12). The substance forms into a lump which, because adhesion is reduced, glides round in one piece (Fig. 13). The substance (a mixture of salt and water) forms bays and promontories, spreads out thinly and is then thrown into folds which make a rugged relief. (Figs. 12, 13, 14 natural size, Fig. 15 enlarged detail.)


14


15

16, 17, 18
If a viscous paste is used instead of a salt mixture, it is also forced into characteristic shapes by the vibrations. The mass may be raised up like a plateau with walls where recesses and projecting ridges are carved out. At the same time the mass is circulating. These are not steady processes: there may be abrupt changes from stagnation to violent activity. (Fig. 16 natural size, Figs. 17, 18 details.)

17

18

approach each other, and then withdraw again. However, there is no constancy in the processes involved. Indeed, phases of immobility alternate with phases of violent movement. A quiescent part is suddenly convulsed with activity. There are moments when, for a short time, "a tremendous amount happens". It is just the same with the motion of the material along the various paths. One of these complexes may be floating along quietly one moment and the next it is rushing madly forward. Directions also change. A simple forward movement (translational motion) may suddenly be followed by a swerve to the side. Again, in Figs. 12–15 there are also small-scale versions of these configurations to be seen. Vibration is impressed on every part of the substance. Here again inactivity, acceleration, movement, countermovement, direction, thinning and clumping, etc. alternate.

Another essential factor in the phenomenology is the nature of the material excited by vibration. Whereas a salt mixture was chosen for Figs. 12–15, a viscous paste was used in the experiments illustrated in Figs. 16, 17 and 18, where the configuration obtained is entirely different. Here structural forms rise like abstract sculptures out of the paste, the pillar-shaped ones being in constant circulation. The processes we saw before are apparent here again. The masses glide round, they may flow together and then continue as a single piece; then they spread out again and divide up, whereupon each part once more reproduces the whole phenomenon in miniature: it displays uniform formation, circulates, and creeps round as a correlated whole.

If a more plastic substance is taken, there is not only circulation but also overlapping and furrowing, because the tendency to confluence has been reduced (Figs. 19 and 20). The features of the process are more durably imprinted on the material. And ever and again regions appear where circulation takes place with bilateral symmetry.

If the experiment is so arranged that a substance comes under vibration while it is solidifying, there are again characteristic relief effects (Figs. 21 and 22). A complex pattern of folds appears and some of these move along in the form of parallel waves (Fig. 22). It is almost as if a landscape were shaped in relief and one could walk there in the mind's eye. On the left in Fig. 21 the front has swung sharply in a curve, marking a turn which took place when the substance was still in a more liquid state. The various forms appearing as the characteristic morphology of these processes always reflect the specific properties of the substances. The relief has one form when the substance is more liquid, another when

19, 20
The nature of the material is also an important factor in determining these vibrational effects. Here a plastic substance has been used. The creeping lobes may collide, one being thrust on top of the other, and produce furrowed valleys. Flowability is diminished and yet even here the substance continues to circulate. (Natural size.)

21, 22
These masses (plaster) have solidified under vibration. The relief is complicated in structure because each of the various stages of consistency the mass has passed through while solidifying has left its imprint. There are large billow-like formations and tiny wrinkles, wave trains succeeding one another, and sudden changes in the direction of flow. It is as if the "history" of the process had been recorded in transverse and longitudinal folds. There is also a tendency for a latticework of folds to take shape. (Natural size.)

19

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23

24

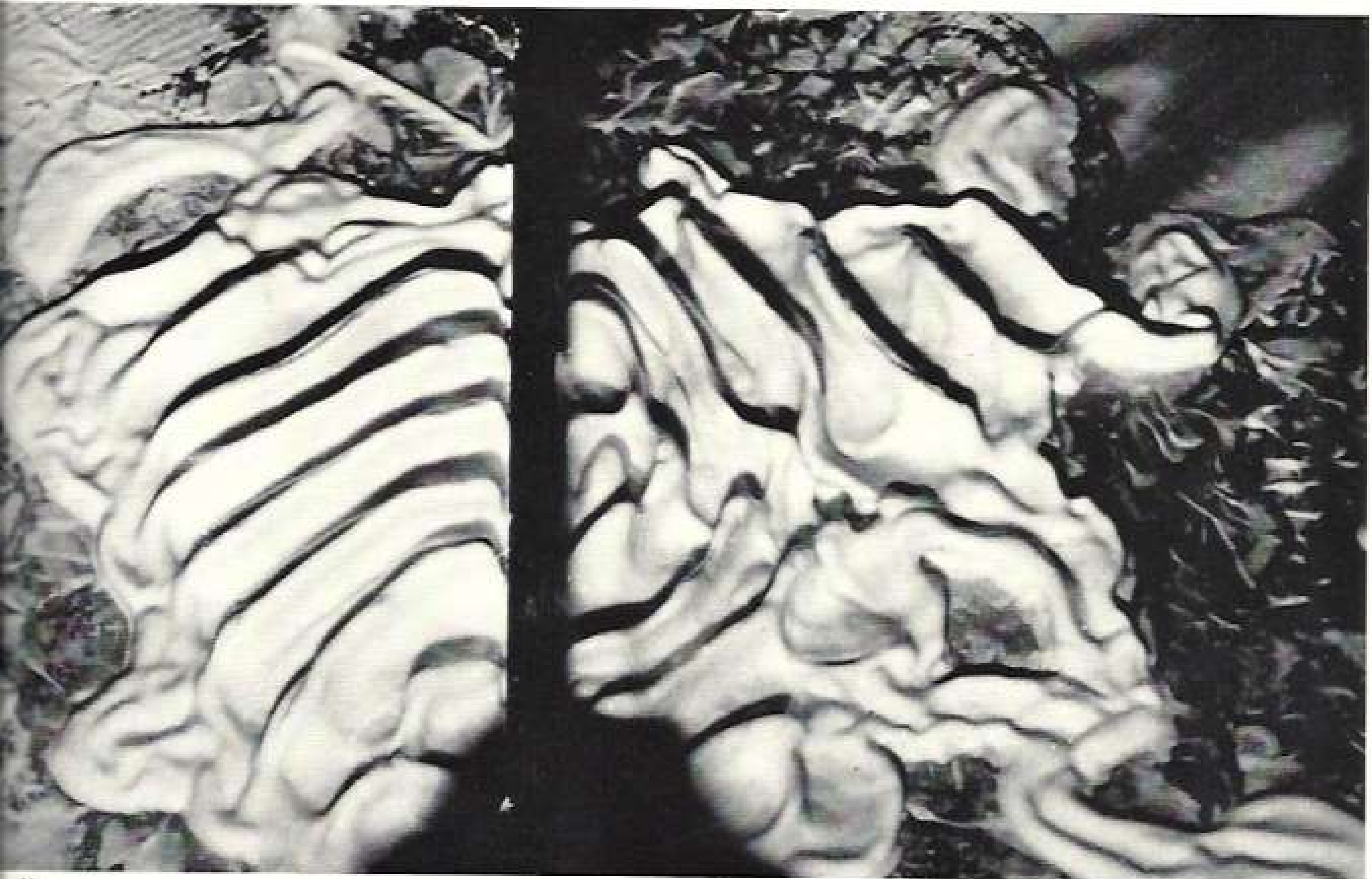
it becomes viscous, another when it is plastic, and another again in the solidification phases. And then, as we have mentioned, the quality of the substance also operates as a specific factor.
Once solidification begins, the situation changes radically. The masses break up under the action of vibration (Figs. 23, 24, 25), but the fragments still continue in motion. In Fig. 23 they are still close to each other but in Fig. 24 they have somewhat "drifted apart". It is still apparent, however, that they originally fitted together. Yet here again the pieces slide round in different directions. In Fig. 24 there is separation, in Fig. 25 approximation, which, when the lumps are solid, causes one "floe" to be thrust over the other. On the left in Fig. 25 a slab has been raised end up. This process of overlapping and overthrusting is, of course, assisted by the reduced adhesion.
If an obstacle is placed in the way of an advancing front of viscous material, the latter is thrown into folds having a certain regularity, and the folds even overlap (Fig. 26).
Figs. 27 and 28 give the reader some idea of the enormous variety of cymatic effects. Here wave trains moving in different directions have woven a patterned tissue. In Fig. 28 an underlayer has first solidified and over it a pattern of folds has been subsequently formed and also solidified.
We can now, so to speak, draw up a list of the phenomena observed when flowable and solid substances are excited by vibration. Our spectrum of

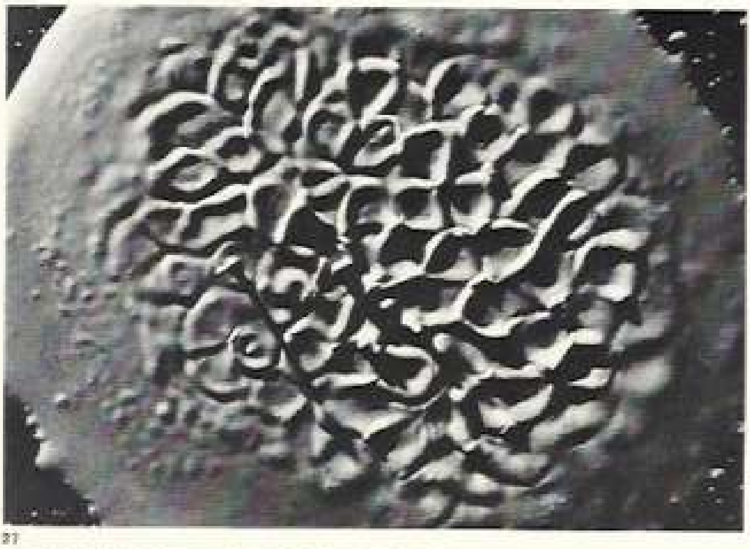
23, 24, 25
Subjecting solidified masses to vibration may cause them to break up. The fragments seen in Fig. 23 have been produced by vibration. These slabs or "floes" are also in motion. In Fig. 24 they have moved apart, but it is easy to see how they fitted together before. The slabs may also overrun one another. In Fig. 25 one slab has crept on top of another. The force driving the fragments apart and also causing them to be overthrust is vibration and nothing else. These polar processes reflect the topography of the vibrational field and depend on the frequency and amplitude. (Approx. natural size.)

25

phenomena is a rich one. And whether the material is formed into clumps or flattened into layers, whether it is piled up or thinned out, whether it is thrown into violent commotion or remains inactive, whether it flows together or flows apart, whether its activities are repetitive or whether it assumes a steady shape – these phenomena all demand a flexible imagination in the observer. It is no use thinking, say, in terms of polarities; one must seek to entertain two opposites at the same time, for polarities proceed simultaneously; masses liquify, separate, clump together and spread out, grow inactive and erupt, etc. And the only efficient causes we can identify are the effects of standing and moving waves, of resonances and interferences, turbulences and circulations. What confronts us, then, is an unmistakable cymatic phenomenology. It is crucially important that, through our experience of these things, we should come to possess them imaginatively and thus be able to formulate concepts concerning them.

26
If the vibrating masses meet an obstacle in their path, series of overlapping waves appear and there is a tendency for the substance to start circulating. In an experiment of this kind there is no disintegration and the vibrating mass accommodates itself to the new situation by undulation.
In Fig. 26 a wooden rod has been placed in the path of the undulating mass; on either side of the obstacle the waves fall into a regular pattern. However, if the substance is more liquid than that used here, characteristic turbulences are seen under these conditions.
(Natural size.)





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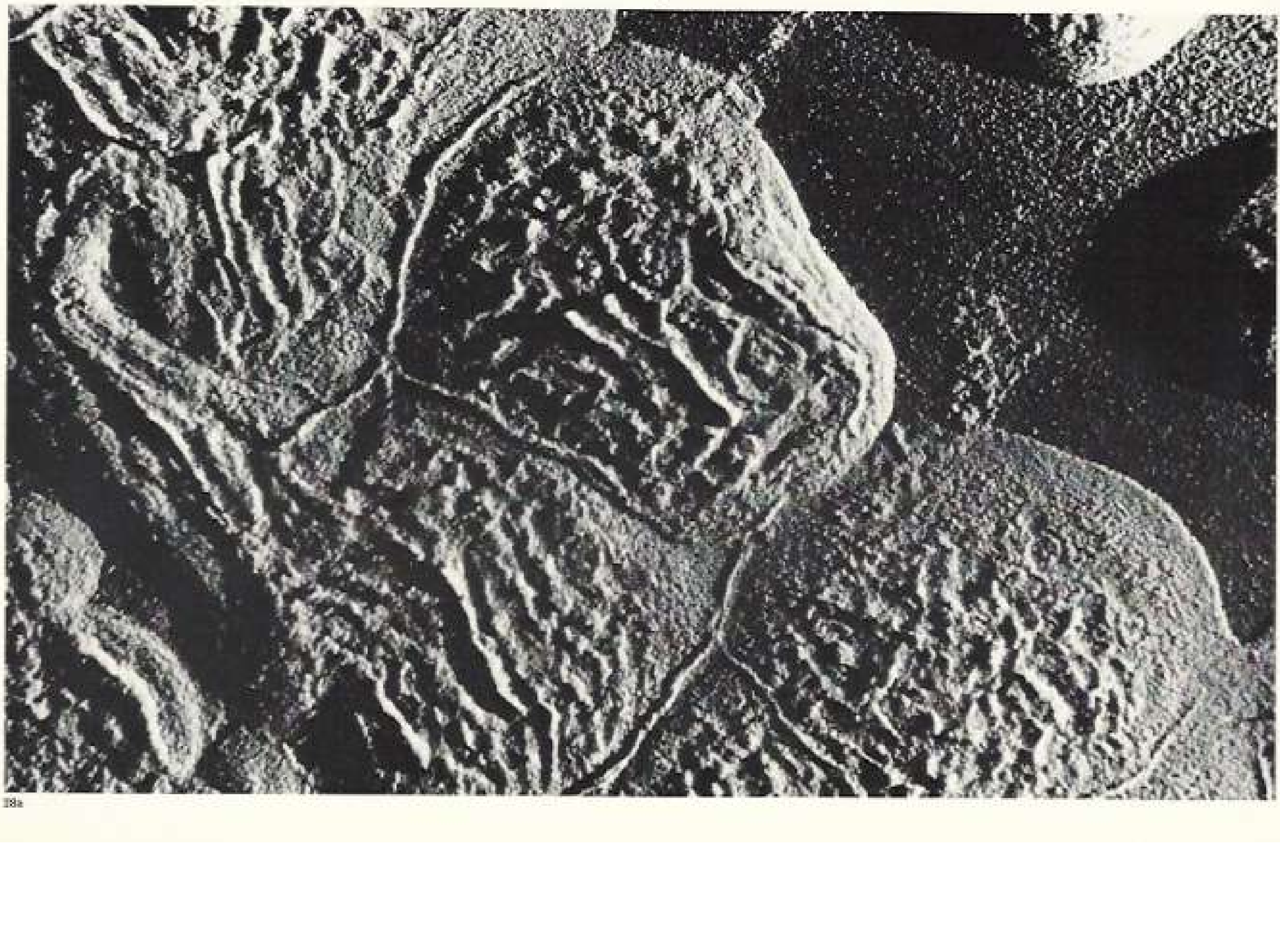


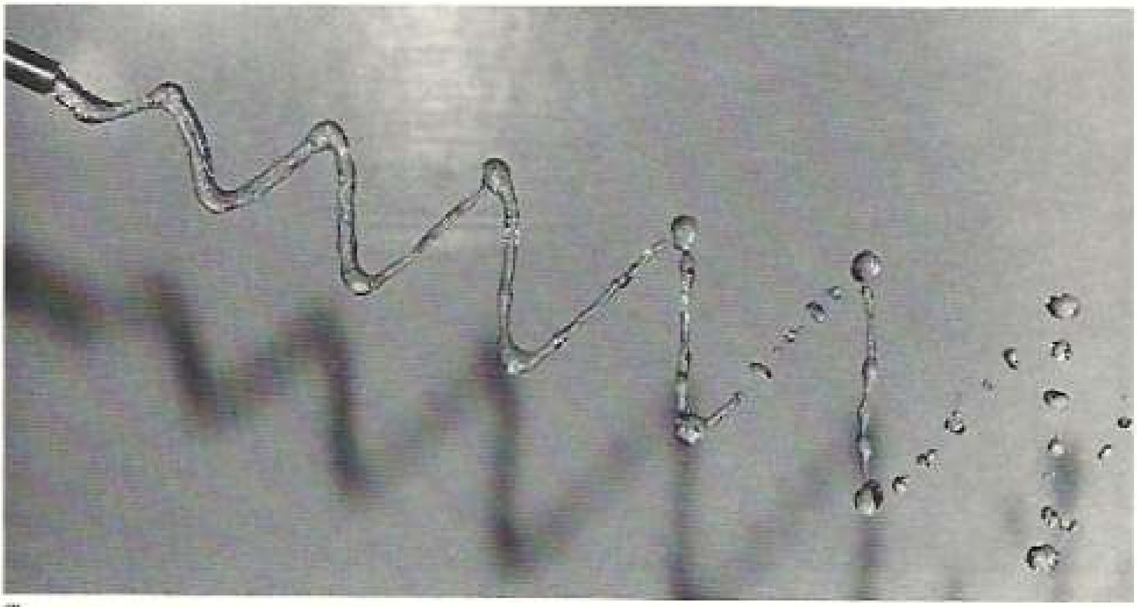
28a

The oscillating water jet

The outflow pipe is excited by sound and this causes the emergent water jet to oscillate. It transmits the periodic impulses it receives into space. The interplay of a number of factors can be seen. Surface tension causes the jet to retain a certain homogeneity. Where it is disrupted, the surface tension is evident in droplet formation. The main feature, however, is the enormous turbulence apparent in the periodic movement due to the high instability of the jet. This periodicity also appears wherever the jet is disrupted (Fig. 29, right). The instability of this interplay of forces can be seen very clearly with the stroboscope. For a brief moment individual drops have an incipient regularity of formation but in an instant become turbulent again.

Curious processes involving attenuations and expansions can be seen. A spiral current appears in the jet time and again. In spite of the complex instabilities the pattern of oscillation still remains prominent. It involves a number of tendencies combined together: there is a tendency for the water to turn into drops, to form a homogeneous jet, and to flow in wave patterns, and at the same time a tendency to produce a regular vibrational pattern. None of these tendencies is ever fully realized; as soon as any single one becomes more precisely defined, it is caught up in the turbulence caused by the prevailing instability.

27, 28, 28a
These figures again exemplify the richness of the structured arrays occurring when a mass solidifies under vibration. The way the patterns are laid down depends on how great a change there is in their physical state. The festoon-like network in Fig. 28 and the sharply profiled ridges and valleys of the pattern in Fig. 27 are remarkable. Fig. 28a shows a curious pattern of areas bounded by lines and themselves sub-divided into similar patterns. This highly varied relief is again the result of vibration. (Natural size.)



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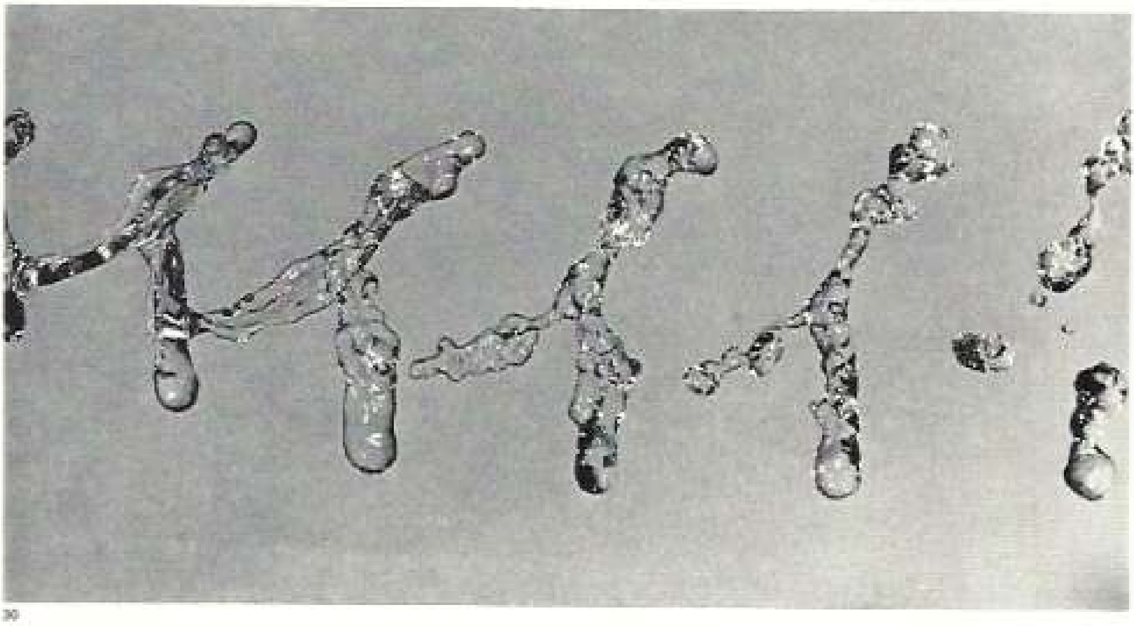

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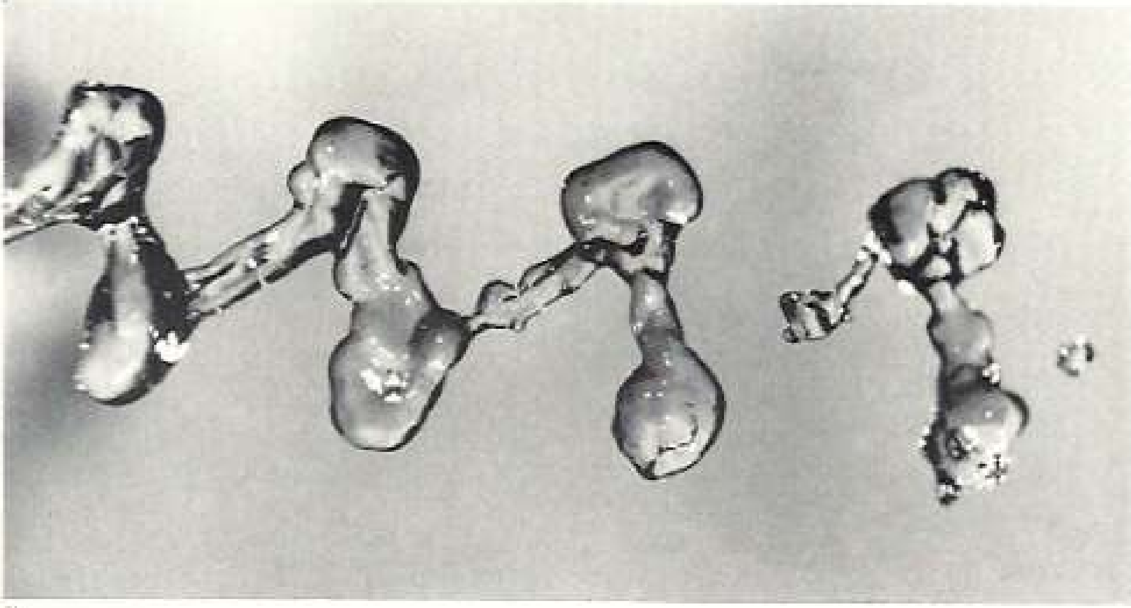


31

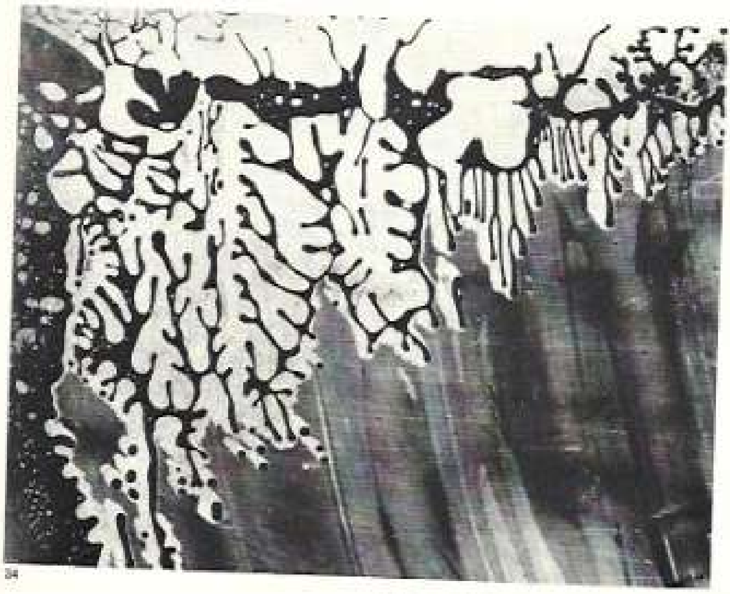
32

29, 30, 31, 32
A vibrational impulse is communicated to the jet of water by the oscillating nozzle, resulting in a complicated interplay. First there is the undulatory path due to vibration, second the tendency for the integrity of the jet to be maintained by surface tension and for droplets to form when the jet breaks up. The stroboscope also reveals regular formations in the drops but, because of the extensive turbulence, they persist only for a fleeting moment (Fig. 29 natural size, Figs. 30, 31, 32 enlarged.)

Vibrational processes in a capillary space

To enable the complex conditions of vibration to be observed as a whole, we allowed liquid to flow into a capillary space bounded on one side by metal foil and on the other by a sheet of glass. On flowing into the space the liquid forms the familiar dendritic pattern. If the glass sheet is plucked away from the foil before vibration is applied, the pattern of dehiscence is seen*. As it is, "everything" remains in a state of inactivity. If the metal foil is now excited by vibrations the whole observed field comes to life. The glass sheet, of course, also vibrates in sympathy. Air enters the empty space at its periphery. Both this air and the liquid, which is stained, are affected by vibration. The inflowing air forms cavities in the film of liquid; the liquid itself puts out fingerlike processes. The vibration causes these formations to appear in series. They make, as it were, a woven texture. And at the same time everything must be visualized as being in lively motion. The processes float and divide. The liquid elements maintain their cohesion because of their surface tension. Fig. 33 shows the nascent process. The lower diagonal surface has not yet been involved. The air is entering from the top. Figs. 34 and 35 show individual parts of the field. The curious fingerlike processes, some of which are forked, look like structures in a hollow organ of the body. They wave about in the air flowing round them. Cord- and festoon-like processes also appear (Fig. 36) which look as if they were invested with folded epithelium and display a fluctuating motion. In Fig. 37 the lowest part has not yet been affected. Above, an almost plant-like pattern is being woven. The impression of a woven texture is, of course, due to the uniform situation generated throughout the field by vibration. If the process affects a single liquid element spread out in the capillary space, say a flattened drop, the configurations seen in Figs. 38 and 39 appear. Once again we see fingerlike processes wafting about. There is interplay between the air and the surface tension of the drop. At the same time the air penetrates the body of the drop and turns it into foam. This foam circulates within the bounds of the liquid configuration and sometimes a pattern of bilateral symmetry can be seen. With its ceaseless movement the whole is reminiscent of amoeboid behaviour. This impression is further enhanced when the formations move around. They proceed along their paths in correlation, i.e. they execute their movements while flowing as a whole. If they thrust out processes to one side, the rest of the body follows up behind. It slides and creeps as a *single whole* round the capillary space. If two such

* Details of the process of dehiscence will be found in "Cymatics 67" (Figs. 99, 100, 101, 104, 105).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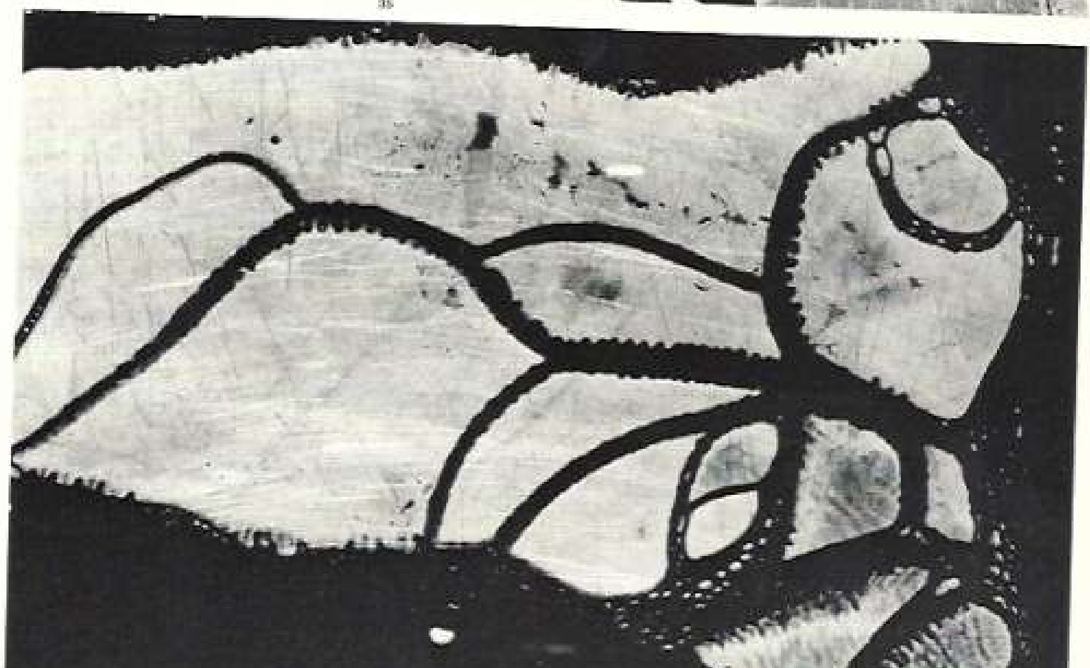
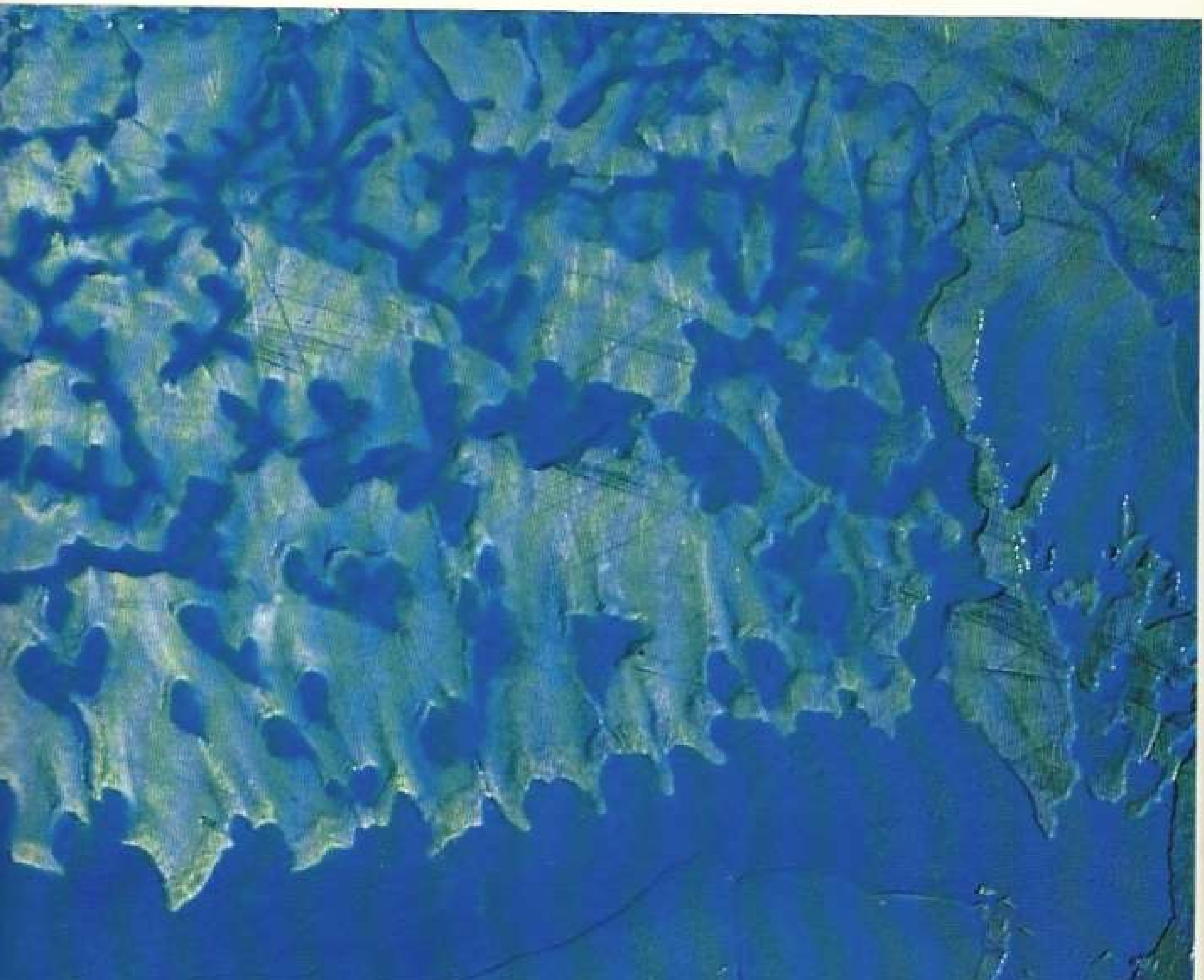

36

33, 34, 35, 36
Air and liquid sandwiched between a sheet of glass and a metal foil and excited by vibration. Thus the walls, the liquid and the air are made to vibrate. In this complex system the air penetrates and forms cavities in the liquid, which in turn branches out into fingerlike processes that waft to and fro (Figs. 33, 34, 35). There are also garland-like cords which look as if they were invested with folded epithelium (Fig. 36). (Fig. 34 is reduced in size. Figs. 33, 35 and 36 are details.)

formations meet, they may merge and form a new unit. On the other hand they may divide and each component immediately functions again as a unit. The relation of air and water can be observed here very well. The elements go through their activities as drops, as bubbles, as foam in a state of flux, in circulations and in fluctuations; and always at the same time can be discerned the tendencies which dominate in the phase in which they exist at that moment. Vibration brings to light the direct interplay of these tendencies. The terms epithelium, hollow organs, and plant are used merely to convey some impression of the original experiment. No analogies or homologies are intended.

37
What can only be described as a "vegetable" pattern has been evolved by the vibration. The forms sprout up but are continuously being shaped and reshaped. Some of them become detached from the substrate and produce structures such as can be seen in Figs. 38 and 39. The whole pattern must be imagined in motion, yet each of the processes is characterized by a typical morphology. "Everything" taking place, however, is the result of vibration. (Photo twice natural size.)



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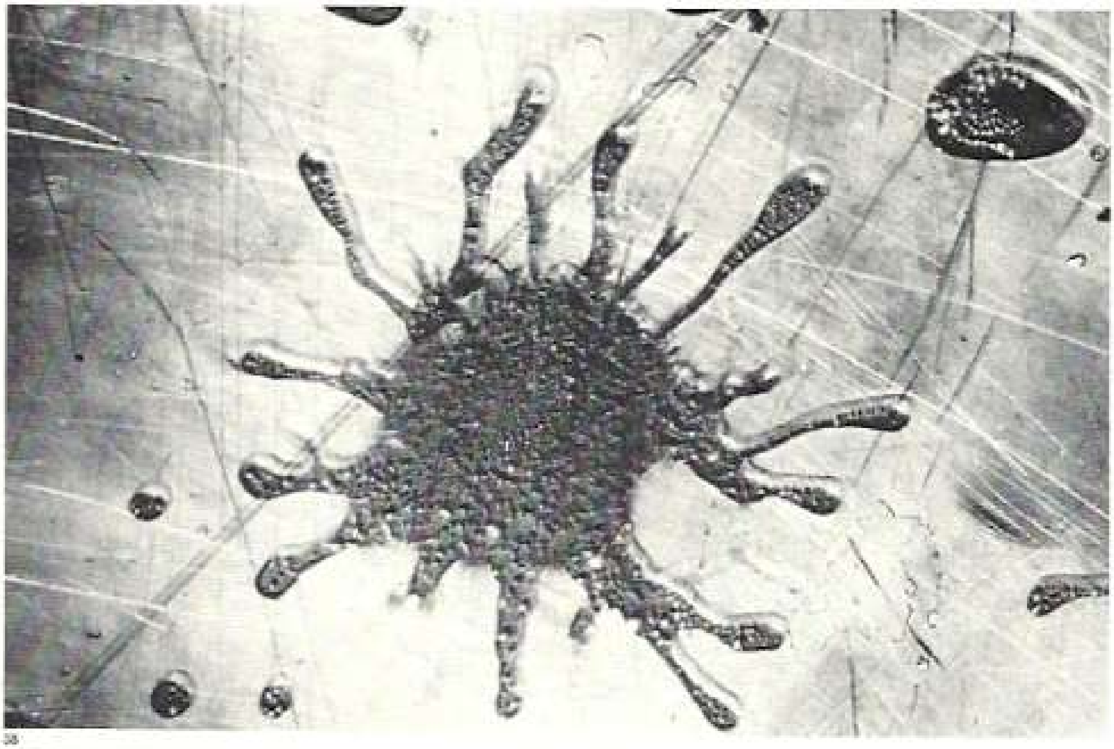

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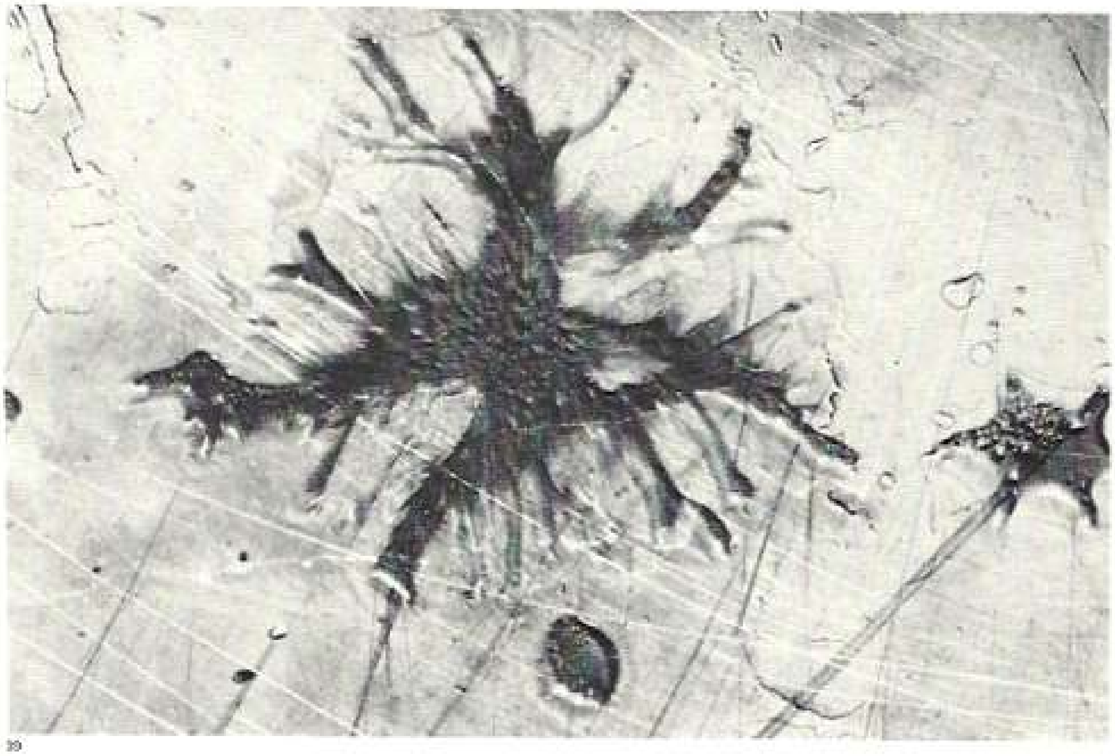

39

38, 39
In these single flattened formations vibrating between the sheets of metal foil and glass there is again an intimate relationship between air and water. On the one hand the processes waft about in the air, on the other the air, sometimes moving in circular currents, penetrates the liquid like a foam. There is also correlation between the liquid systems as they move round in the capillary space. (The figures are slightly enlarged.)

Vibrational figures revealed by schlieren photography

Since it is difficult to visualize and comprehend the conditions generated by vibration in complex bodies (curved surfaces, bells, violins, etc.), the obvious thing to do is to use a method which manifests the processes directly in the object itself. To this end we chose the schlieren method in which incident polarized light is used to detect the strains in a transparent object by double refraction. We polarized the light of the stroboscope itself and allowed it to fall on a transparent sheet of plastic which was made to vibrate. With the aid of the analyser we could then observe what was happening in the plastic sheet under vibration, and found that characteristic vibrational patterns appeared (Figs. 40 and 41). It can easily be shown that these are due to oscillation and not to other strains by following with the stroboscope the movements of the diaphragm generating the vibration and comparing them with the movements of the vibrating sheet, where the pattern of light and dark effects depends on the frequency employed. In this way the oscillatory process can be followed in the material itself. Many objects, of course, are not transparent, and consequently models must be made in the shape of these objects. They can be cast in artificial

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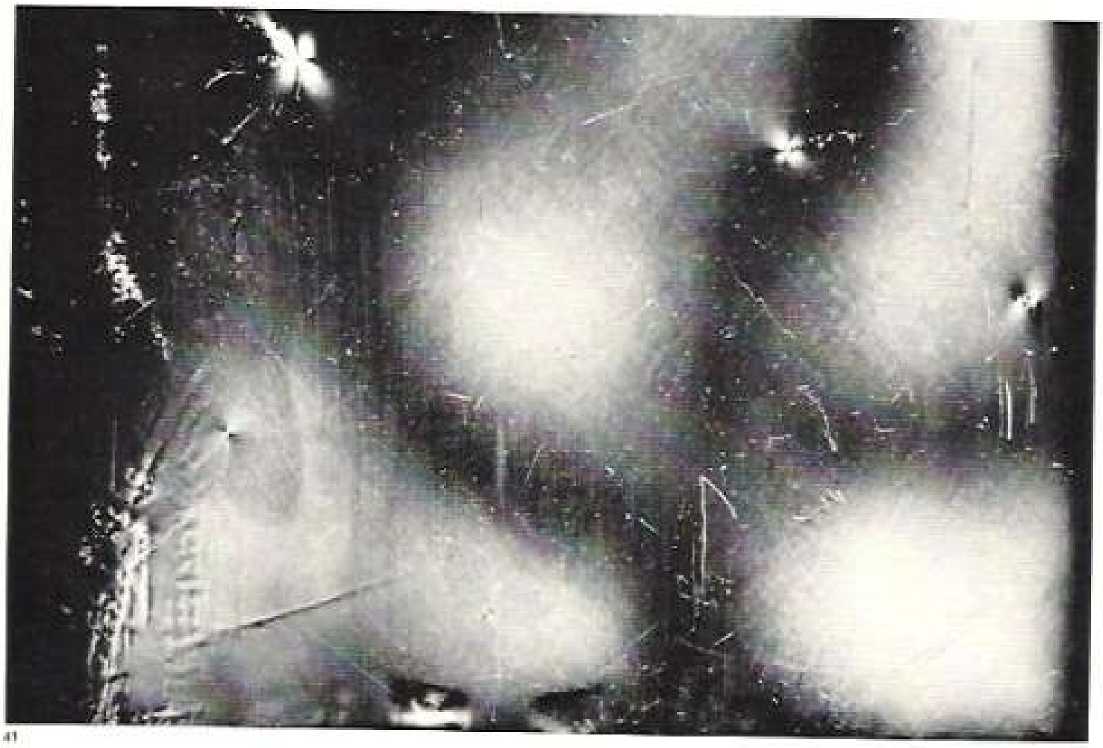
40, 41
Vibration in a transparent sheet of plastic visualized by photoelastic methods. Polarized light and double refraction clearly disclose the tensions produced in the material by vibration. (Slightly enlarged.)



41

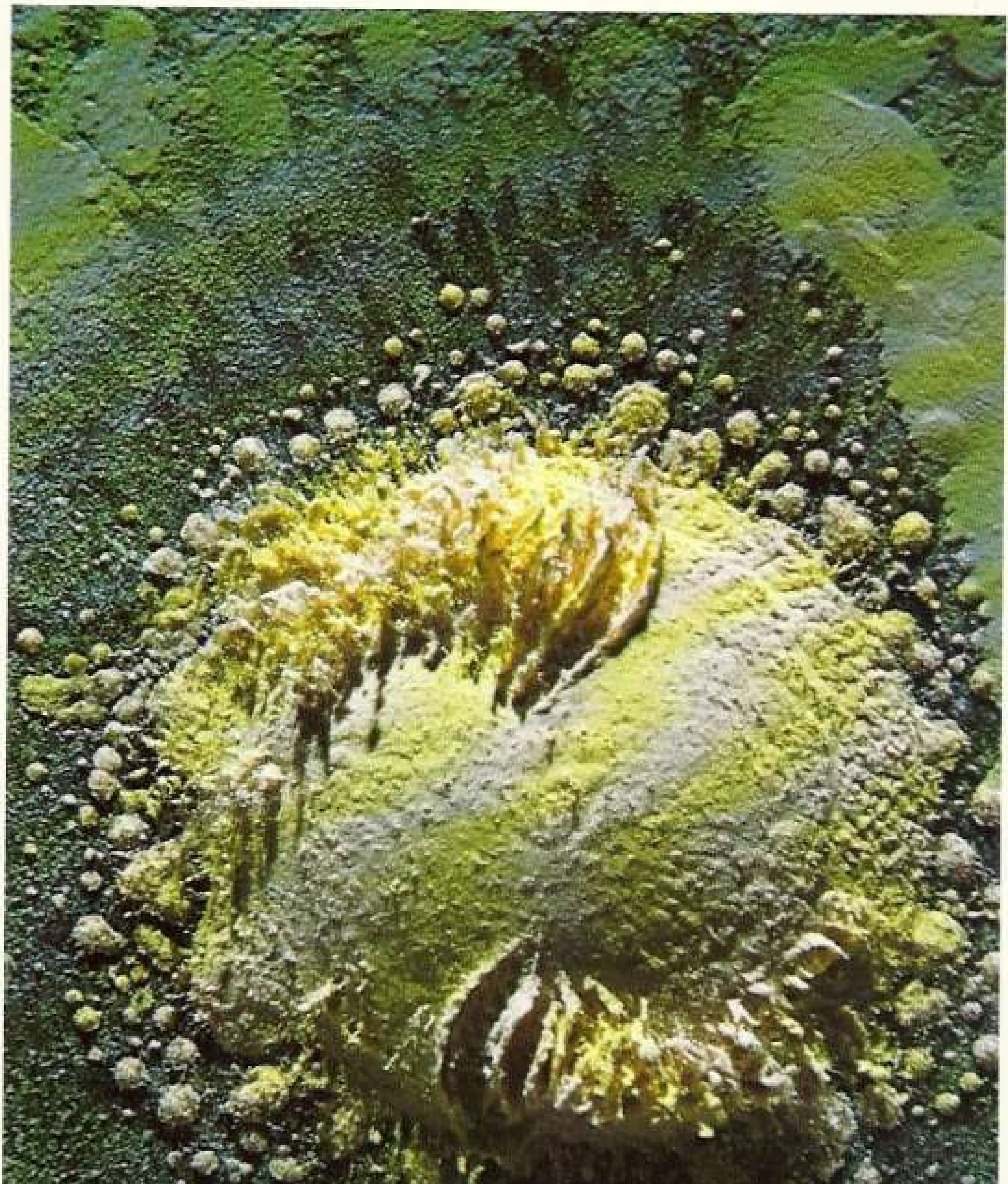
resin and must be free from internal strains (well tempered). In accordance with similitude relationships a true picture of the vibrational process can be obtained. Another technique is to study the reflected light of an object coated with a varnish giving a schlieren reaction. The process with the models, however, yields very serviceable results.

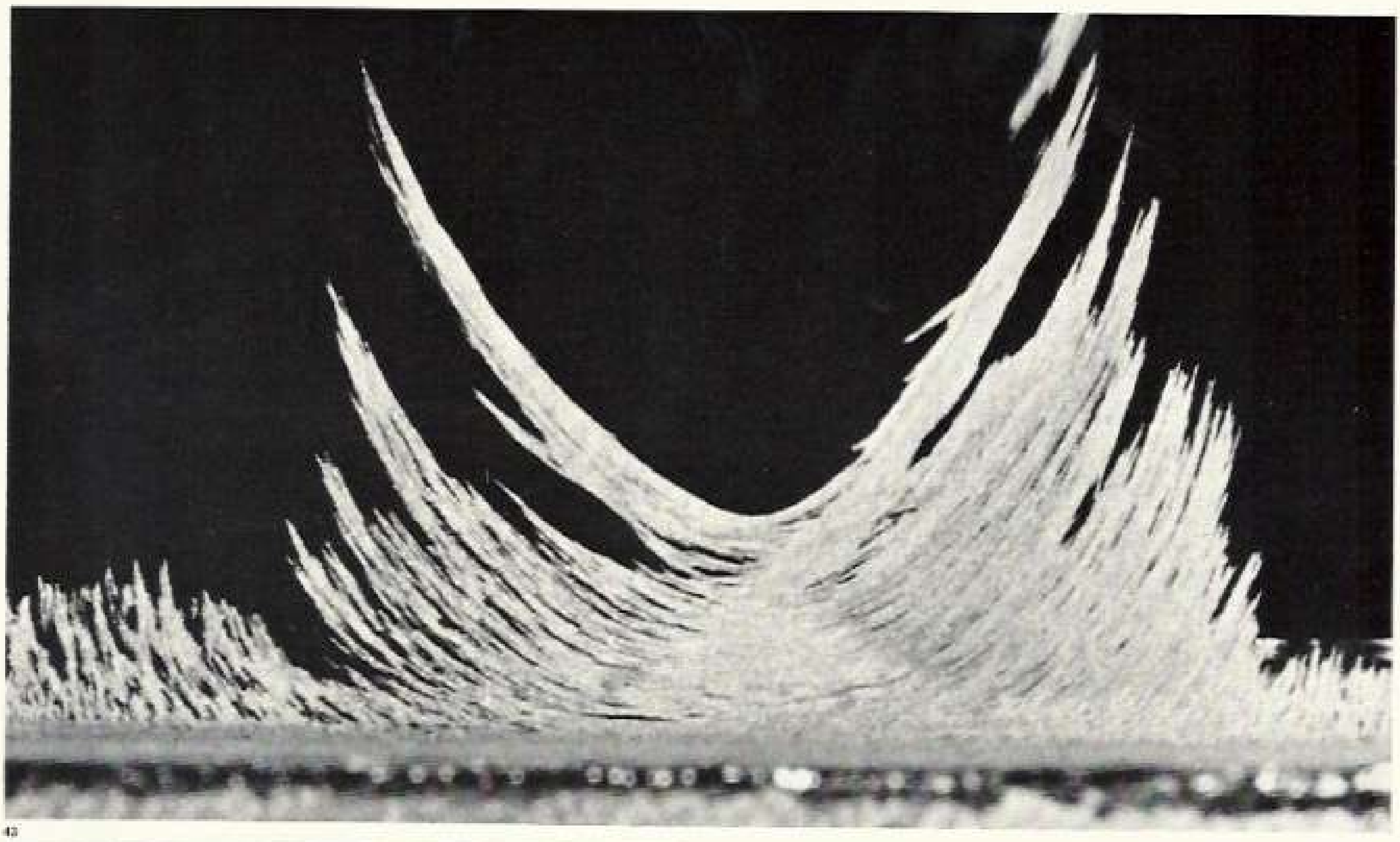
Rotational and to-and-fro effects

Lycopodium powder (spores of the club moss) is an exceptionally homogeneous material, consisting of particles of uniform shape. "Cymatics 67" reported on some series of experiments with this powder. The round heaps formed by vibration are in a process of systematic circulation: the particles at the bottom are transported from the periphery to the centre and from the top back to the periphery again. Looking down on the pile we see the powder come welling up in the centre and then streaming away again to the periphery. At the same time, depending on the intensity of the vibration, various specific regions and structural patterns are formed, and furrows may even appear, sometimes in a concentric arrangement. As the volume of the tone is increased, the material is flung out of the pile, and small eruptions occur particularly at its edge but also within its boundaries. And then there is also an inflow of new particles which are likewise thrown up in small fountains. If we watch these processes carefully, we see that these powder fountains also trace out paths within the area of the heap, appearing in large numbers and scurrying over the curved surface. The tracks they follow conform to a mainly concentric pattern. Indeed, it becomes increasingly obvious that the rotary motion is a systematic process. While some of these eruptions rotate in a clockwise direction, the motion of others is counterclockwise. If two such eruptions collide, the process ceases. The experiment can even be arranged so that the particles circulate first to the left and then to the right as they spurt up in fountains. There is a real to-and-fro effect with the motion alternating in direction in a highly regular way. Once the right adjustment has been made, the whole process is enacted at the same tone and the same amplitude, the system moving to and fro in an orderly manner. There is no actual transportation of the particles; what happens is that the powder always spouts up at one and the same spot. Sometimes a connection can be seen between this pattern and the furrows formed by the circulating currents, but the rotary motion may appear without any such link being apparent. Conversely very lightly-marked furrows, which disappear almost immediately, can be seen behind the moving "fountains". A particularly striking fact is that these violent local reactions do not intrude destructively into the circulatory process. The phenomena proceed regularly side by side while a pattern of ordered unity is maintained. By very fine adjustment it is even possible to produce one circulatory phase without the other. The following phenomenon is then observed (Fig. 42): two small eruptions appear in the circular heap steadily circling at the opposite ends of a diameter. In the photograph they are circling in a clockwise direction. The spouting particles form a series of frontal wavecrests with a state of almost complete inactivity following in their wakes. One must imagine that the heap of particles welling up at the bottom of the picture has just moved to the right, and the one at the top to the left. The areas in between are meanwhile quietly circulating, but in a moment the disturbances will course through them again. The periods of revolution are, of course, much slower than the vibration. At a frequency of 66 cycles per sec. in one experiment, for example, there were about 30 revolutions per minute. It is particularly striking that the rotary waves move diametrically opposite to each other, and it is characteristic of the phenomenon that they move as *one* process on the same diameter.

What the phenomenon involves, then, is this: a number of eruptions move in a to-and-fro manner and obliterate each other, or the eruptions move in a to-and-fro manner *one* pair at a time and take over from each other, or just one single pair rotates uniformly with no to-and-fro motion. The form the process takes depends on frequency, amplitude, the quantity of material and the topography of the vibrating diaphragm.

42
A round heap of lycopodium powder (about 4 cm. in diameter) is made to circulate by vibration. At the same time two centres of eruption rotate at diametrically opposed points of the pile. Rotating first in a clockwise and then in a counterclockwise direction, this wave produces a kind of to-and-fro effect. The two points where the powder is flung up must be visualized as running the very next instant through the quiet areas of the periphery; in their wakes activity immediately ceases again. The processes of rotation and circulation proceed uniformly. Frequencies can be set at which the rotation runs in one direction only. It looks as if a "diameter" were rotating.





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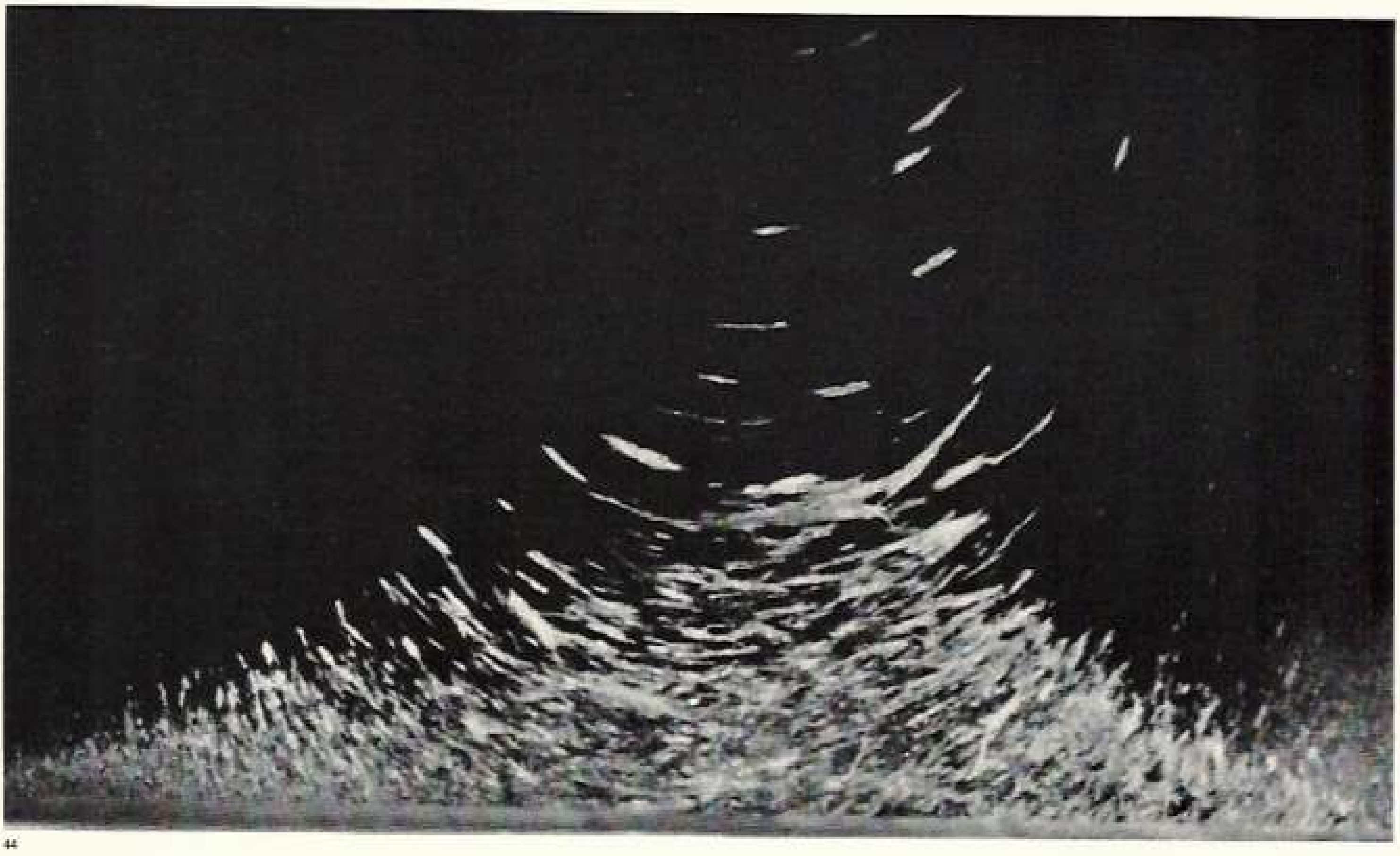


44

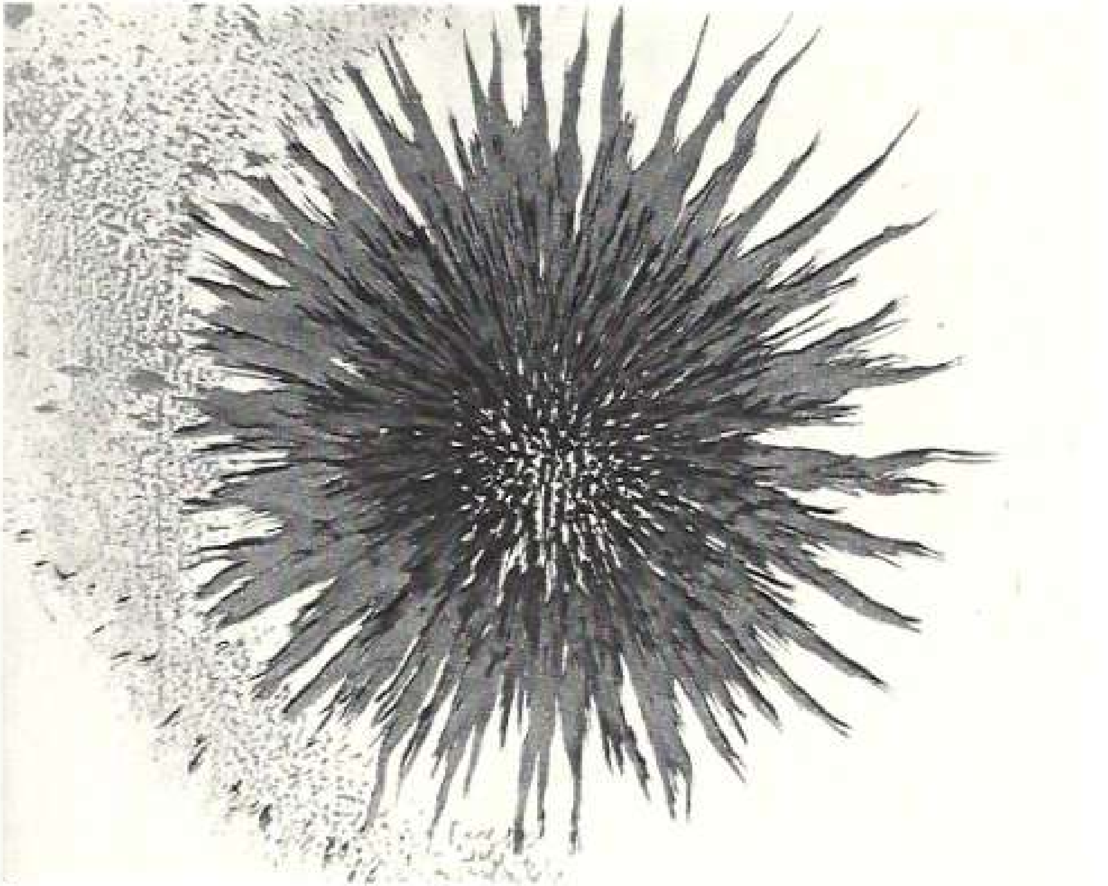
Ferromagnetic masses in the magnetic field under vibration

As adhesion to a supporting surface is reduced when it is vibrating, and as a material, whether composed of particles or a viscous paste, becomes more mobile and liquid within itself under vibration, it is to be expected that forces will produce a different pattern of effects when adhesion and cohesion are reduced. This phenomenon was investigated by subjecting ferromagnetic material to vibration in a magnetic field *. First, fine iron filings are placed in a magnetic field and the supporting surface is made to vibrate. On the one hand the familiar phenomena of attraction make their appearance (Figs. 43, 44) and, on the other, the equally familiar polar figures (Fig. 45). Vibration which, of course, also operates in the air over the diaphragm, causes the particles, as it were, to be held in suspension. In Figs. 43 and 44 the iron particles in the magnetic field must be imagined to be moving with a certain degree of freedom. They hover and fly round in the magnetic space. A curious effect can also be observed in the polar figures. If the vibration alone were acting upon the iron filings, there would be conglobations in a process of circulation. But here there is the additional factor of the magnetic field impressing the polar pattern on the iron filings. But the action of the vibration does not cease here: the polar figures are also divided into tapering zones extending out to the periphery and all in the process of circulation. In a radial direction there are masses of powder which are circulating at right angles to their long axis. Fig. 46 shows a single "roller" in a process of circulating several ways at once.

An obvious question to ask was: What happens if a coherent ferromagnetic mass in a magnetic field is subjected to periodic excitement? What happens to this mass if the magnetic field is even moved and its direction and strength are changed? How will this mass follow the magnetic pathways? How will it be affected by its own magnetizations? To find an empirical answer to these questions, a viscous paste was thoroughly mixed with iron filings, producing a homogeneous ferromagnetic mass. Using this mass, experiments were performed during which frequency and amplitude were varied and, more especially, the magnetic influence was also varied. The strength and direction of the magnetic field were changed but, most important of all, it was also shifted. The photographs in Figs. 47–60 capture moments from these experiments. The whole must be imagined in a state of continuous flow with the morphology caught by the camera clearly in evidence. Flowing sculptures might be an apt description.

43, 44
Oscillation reduces cohesion and adhesion. Accordingly iron filings, say, acquire new degrees of freedom in their movement. The iron filings in these photographs must be imagined to be hovering and flying about, as it were, as a result of the vibration. This movement affords direct insight into the integrity of the magnetic space at all times. (Natural size.)

* Similar experiments were reported in "Cymatics 67" (Figs. 106, 107).



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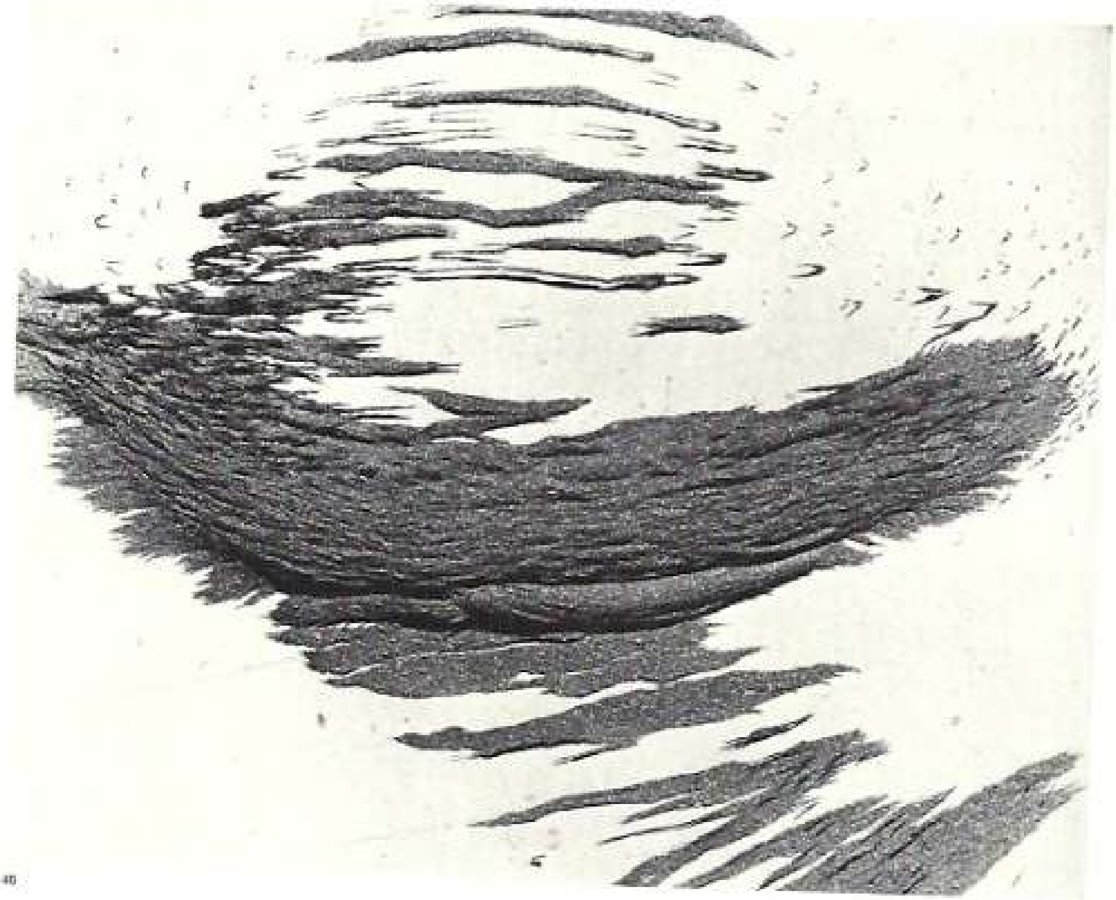
45, 46
The figures round the magnetic poles are also "brought to life" by the vibration. Because adhesion and cohesion are reduced, these patterns are in continuous motion. Circulation is the most prominent feature. Fig. 46, which is slightly enlarged, shows such a roller formation which has been created by circulation. The vibrational field confers a unified wholeness upon these phenomena which is apparent in the way they are continually being integrated.

Omit the magnetic field and we are left with conglobations due to oscillation, pulsation and circulation. Now re-impose the magnetic field, and the mass pushes upwards (Fig. 47) but does not burst asunder. The configurations appearing here are essentially spatial in character and it would be more appropriate to speak of *magnetic space* than lines or fields of force. Serial structures stand out from the general pattern (Fig. 48). Then the figures put out new branches (Fig. 49). They grow upwards like plants or leaves (Fig. 50). But the most prominent features of all are turning and helical formations in which a pronounced twist appears. The formation begins to rotate. In Fig. 51 a curved, S-shaped form can be seen. The photo has perpetuated a single moment. What actually is happening is that the formation is turning on its long axis and consequently the impression conveyed to the eye, for which the process is too

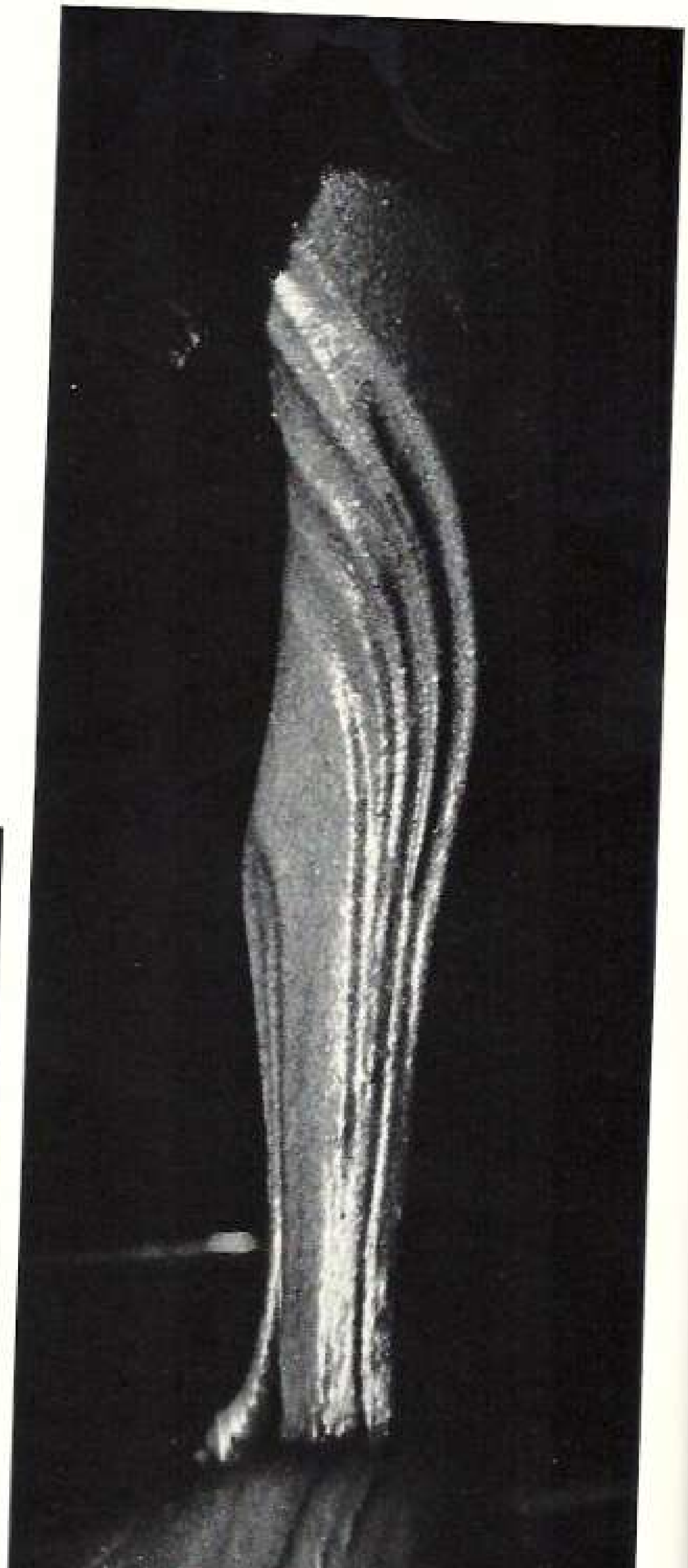


fast to be resolved in detail, is of a dancing caduceus. This process is steadily continuous. When, however, the mass sprouts leaves (centre Fig. 50), and tips appear with like magnetism, these repel each other and the whole figure collapses. At the same time the outgrowths flutter and rotate. A spiral motion can often be clearly seen in the rising columns.

Under other conditions there are upfoldings which rise up to form arches (Fig. 52). These structures tower up and tend to flow along a path (Figs. 53, 54, 55). Then they thrust out again into space (Fig. 56), and in the interplay between the cohesion of the mass and the magnetic force they spread, grow thin, and peter out. Forms tower up displaying the configuration wrought by magnetic force and oscillation (Figs. 57, 58, 59). Large leaflike walls take shape and sway to and fro (Fig. 60) in the magnetic field.

47, 48, 49, 50, 51, 52
To make magnetic and cymatic effects in space visible, iron filings were mixed with a viscous liquid. This "emulsion" was then subjected to vibration and a magnetic field at one and the same time. The masses rear up (Fig. 47), or grow into serial, branch-like, or leaf-like forms (Figs. 48, 49, 50). Sudden repulsions can be observed in these budding structures when two of the processes are both magnetized alike. Often a twisting movement appears. In Fig. 51 the small S-shaped figure is rotating and in the experiment looks like a tiny dancing caduceus. (Approx. natural size.)

47



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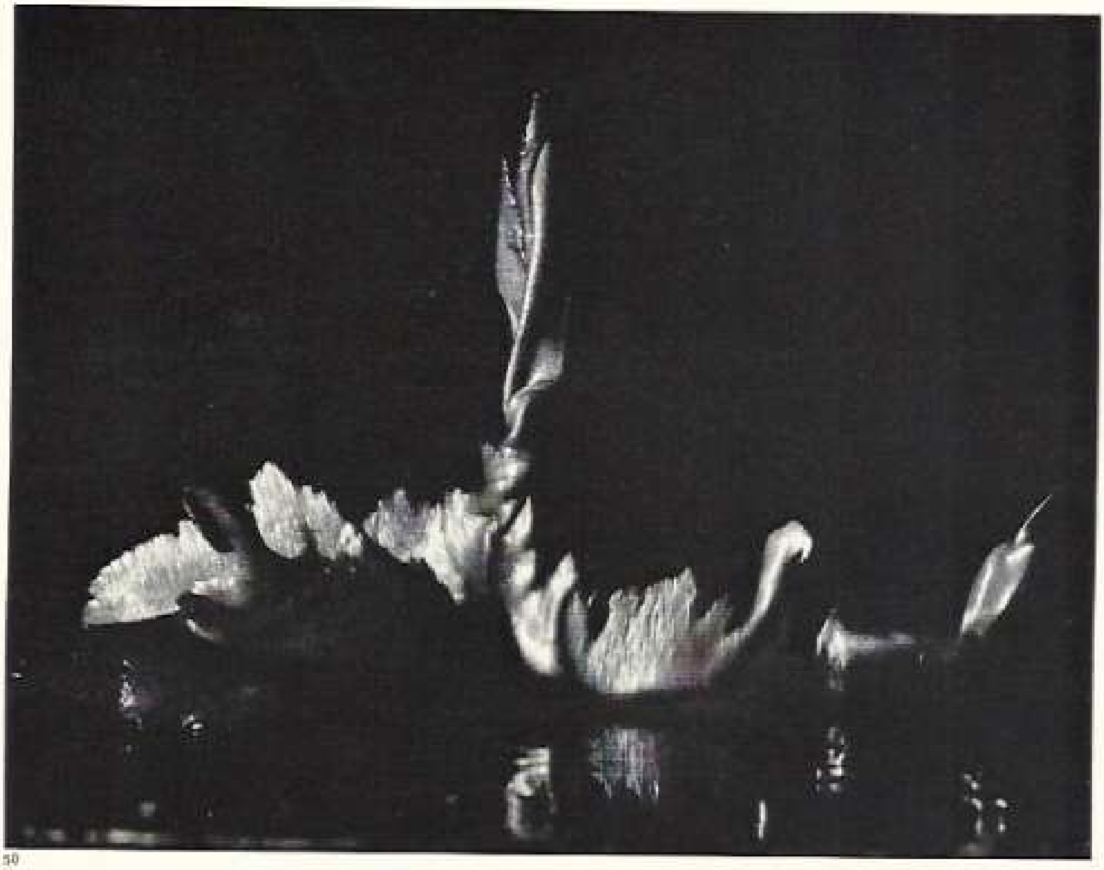
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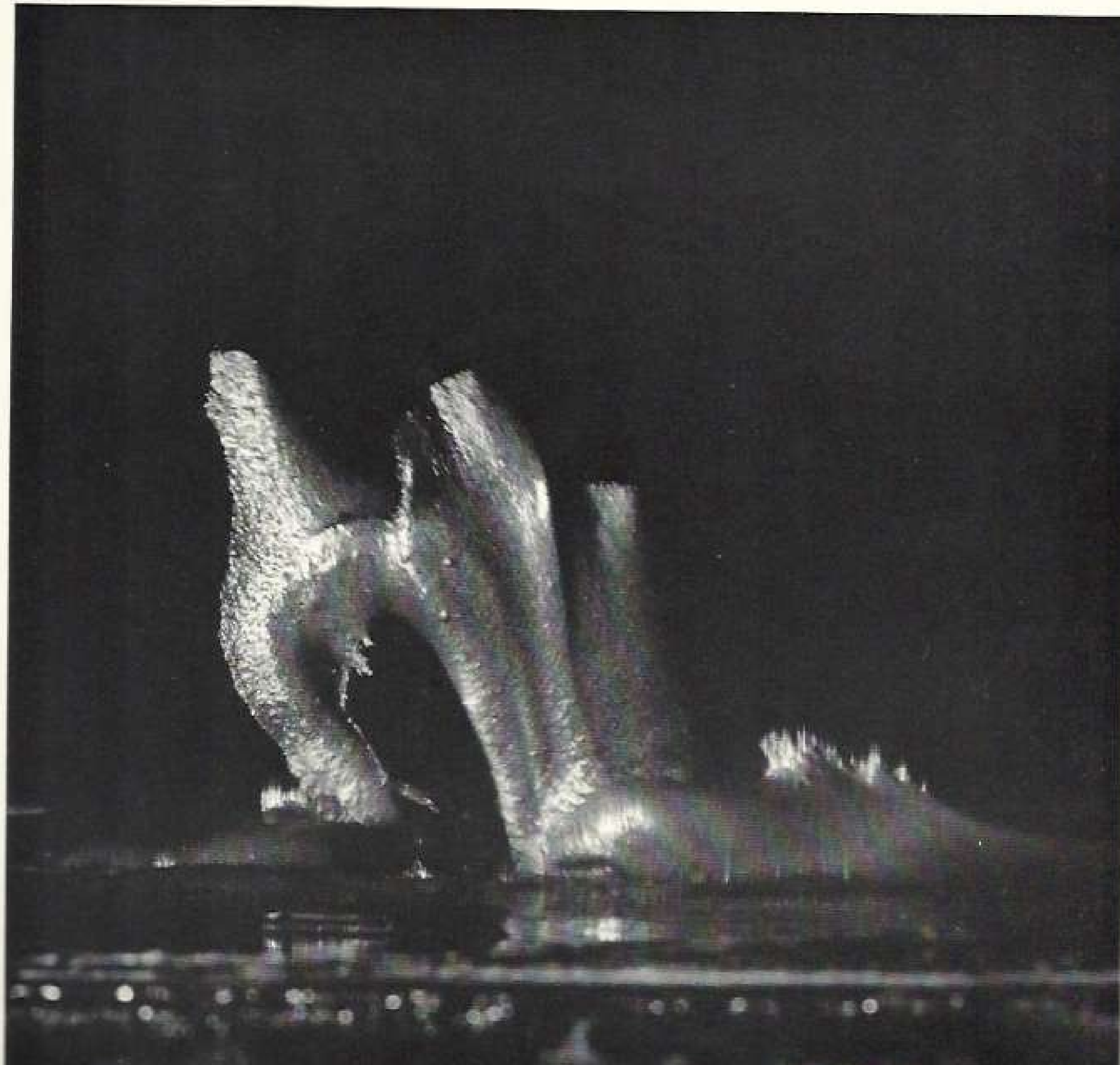
51

52

Here Nature reveals an abundance of sculptured forms, and all of them, it must be remembered, are the result of vibration. If the tone ceases, the mass "freezes". Looking at these vibrational effects, it would be no exaggeration to speak of a true magnetocymatics with its own dynamokinetic morphology. Experiments like this based on pure empiricism stimulate the plastic imagination and develop the power to feel oneself into a space permeated by forces.
It might be added that we have started experiments with physical plasma. A small element reacting magnetically could be made to vibrate by the impingement of sound. We have not yet succeeded in producing configurations because of the small dimensions but appropriate structural patterns may be confidently expected. Experiments of this kind are being continued.

53
The ferromagnetic mass placed in the magnetic field can conform to the pattern of its lines of force when excited by vibration. Adhesion and cohesion are reduced. Under these conditions the characteristics of magnetic space are visualized. What we see in Fig. 53, then, is not a rigid arch but, so to speak, a flowing piece of sculpture. (Slightly enlarged.)

60



54, 55, 56
These figures show the plastic pattern of movement displayed by a ferromagnetic mass in a magnetic field under the influence of vibration. The mass flows in the magnetic space and reflects its configurations. It writhes, roars up, and stretches out but always in a way that reflects the situation in the magnetic field at that particular time. (Natural size.)

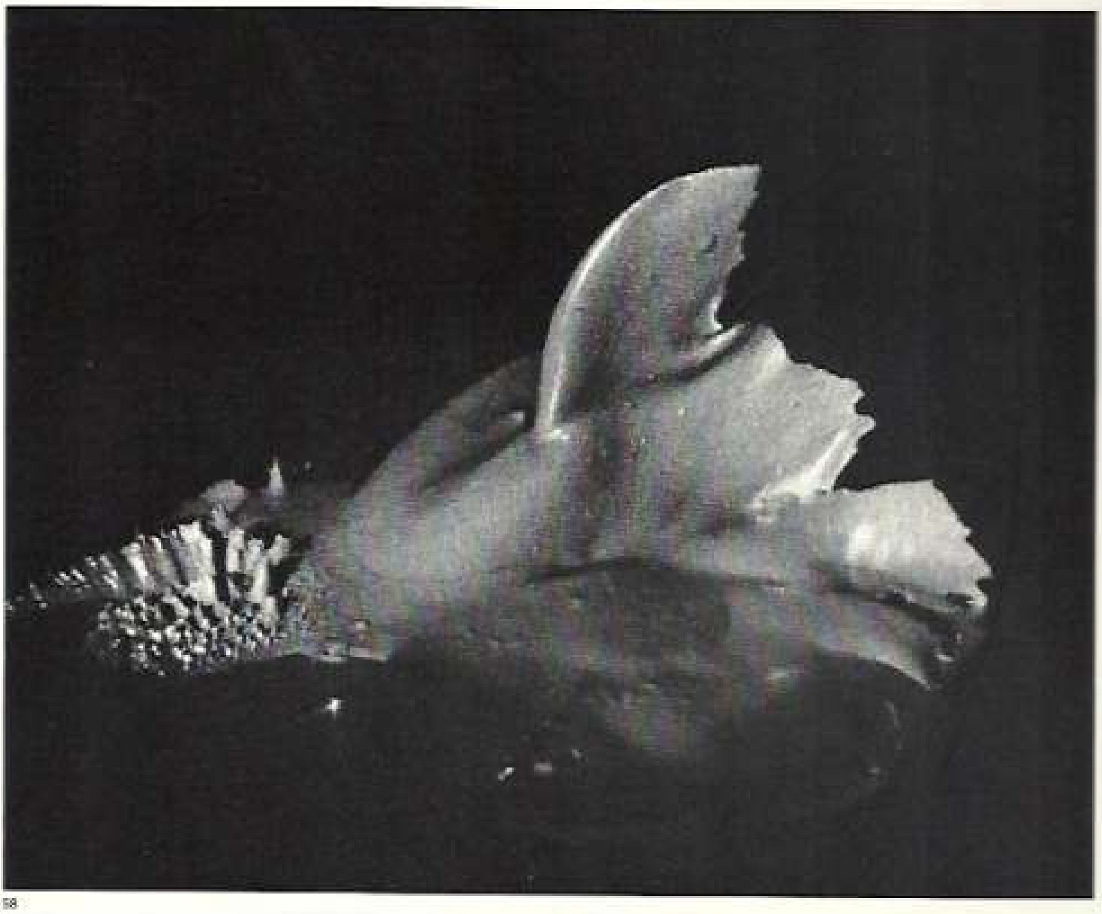
55

56

62

57

57, 58, 59, 60
Depicted here are additional processes taking place in magnetic space. The vibrational field confers certain degrees of freedom on the material by reducing its cohesion and adhesion. The mass becomes more "fluid", more liquid. These flowing sculptures differ from each other in an extraordinary variety of ways. They clump together and are then drawn out in serpentine threads which squirm and writhe. But there is no real continuity about the performance. The flow often stops abruptly and then begins again with a rush. The flat surfaces may begin to flap and flutter. If the fingerlike processes have the same magnetic polarity, they are mutually repelled: the whole structure collapses and then begins to take shape again. In this way the relationships prevailing in the magnetic space are revealed in their gradients and varying strengths. (Figs. 57, 58, 59 natural size, Fig. 60 somewhat enlarged.)



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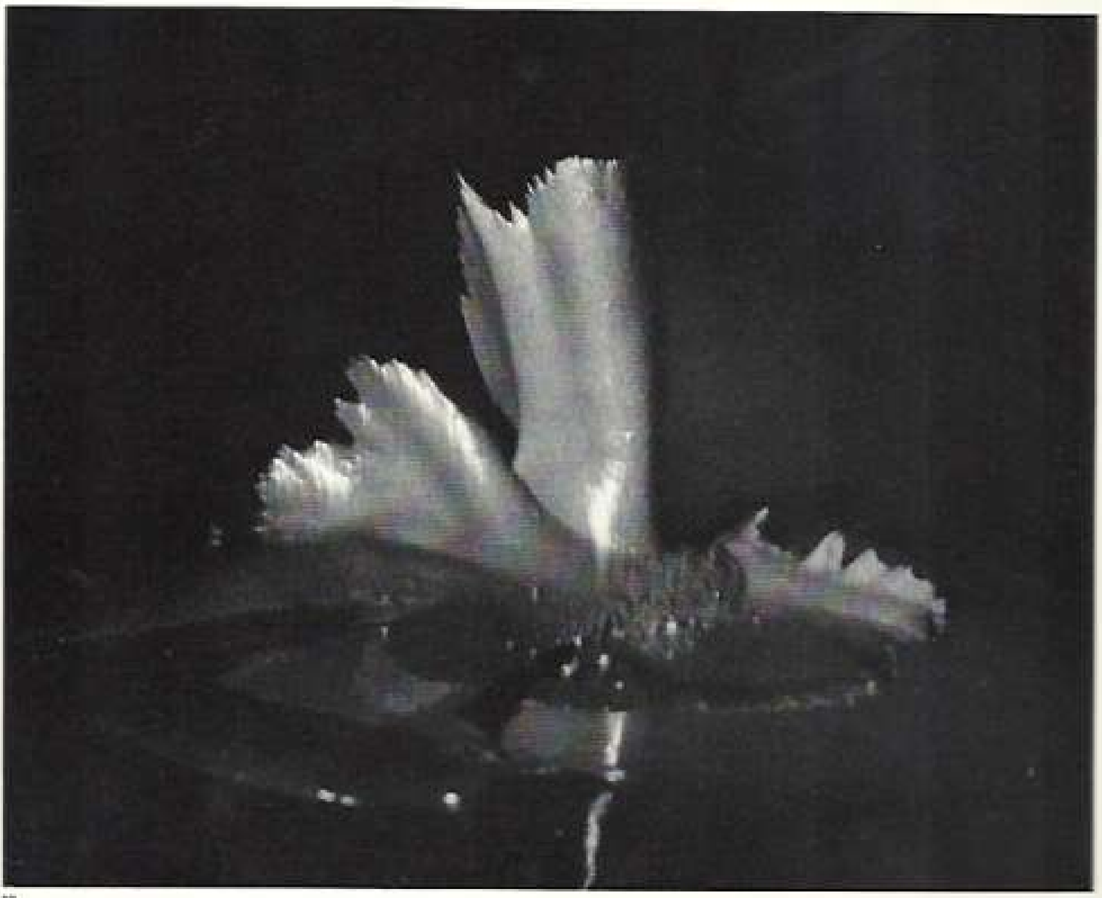

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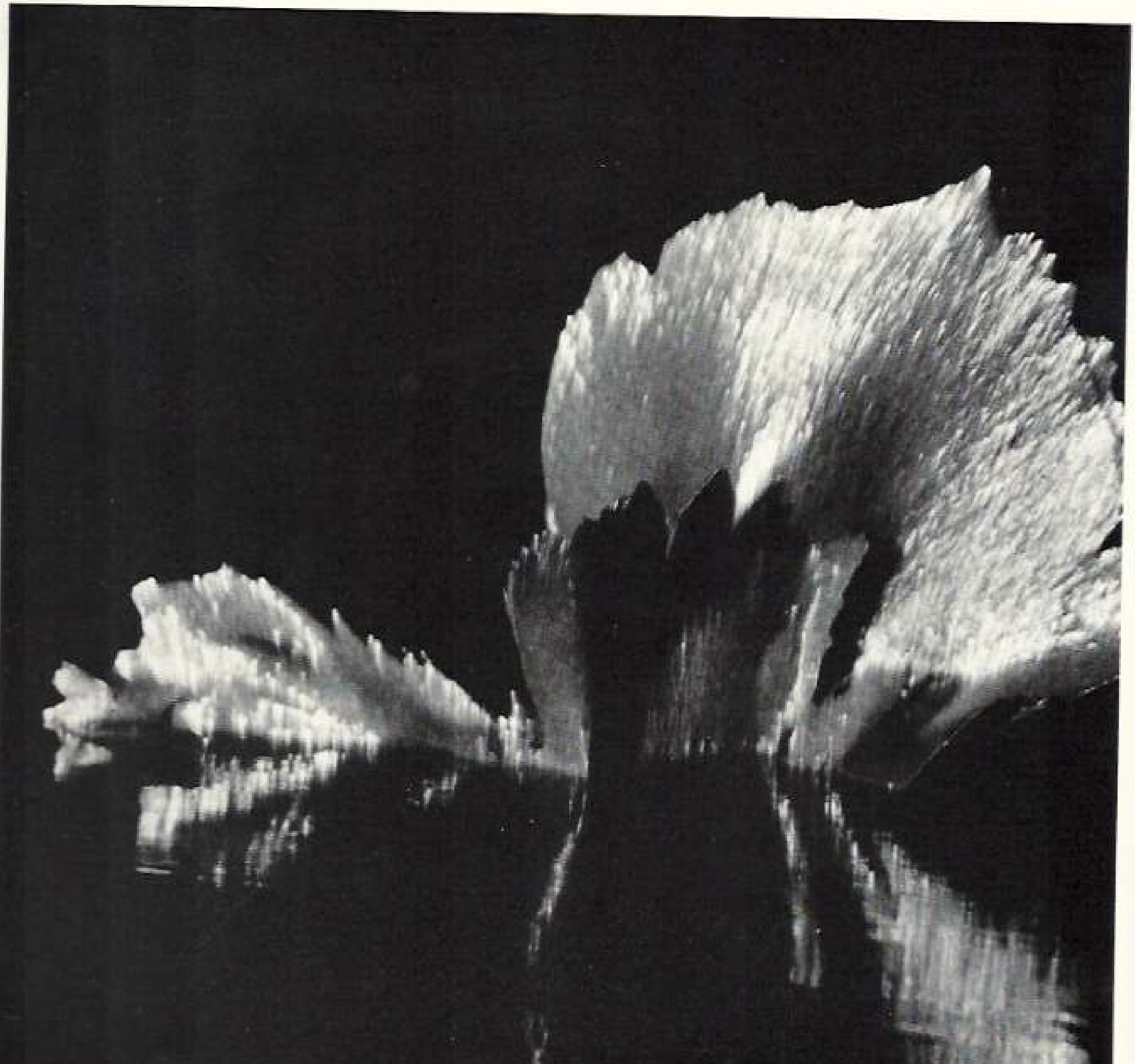
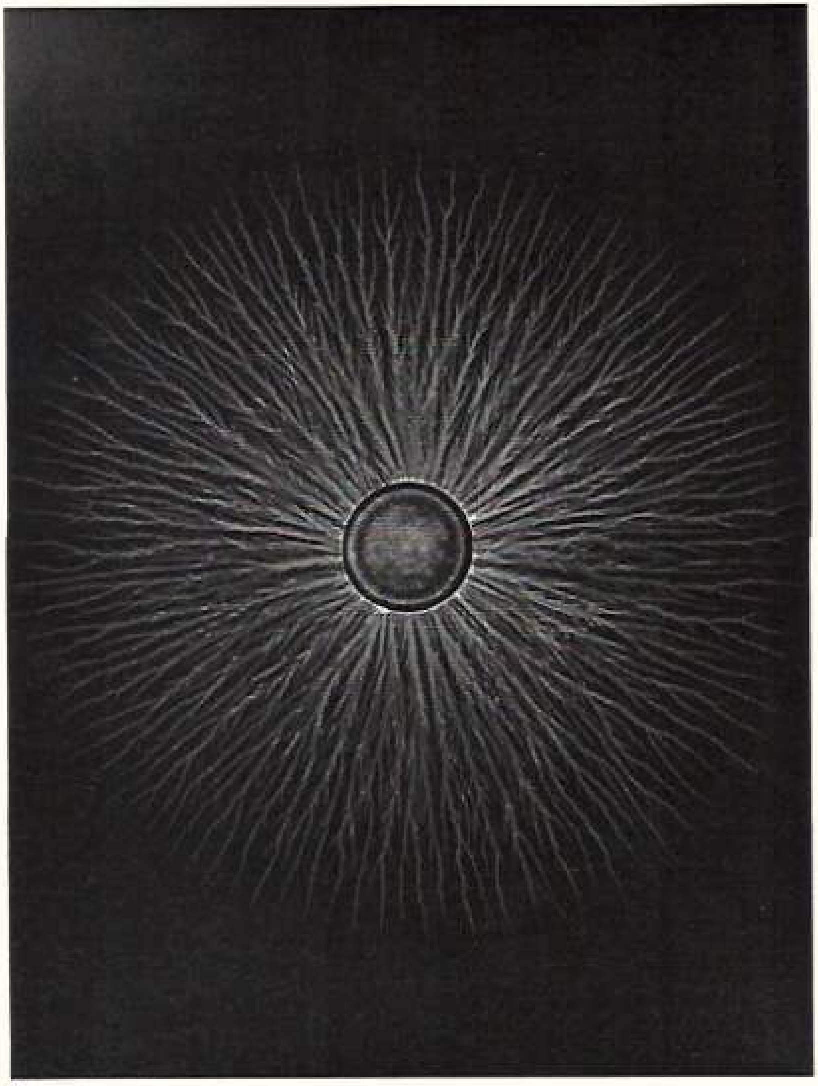


The morphology of Lichtenberg figures. A carrier system

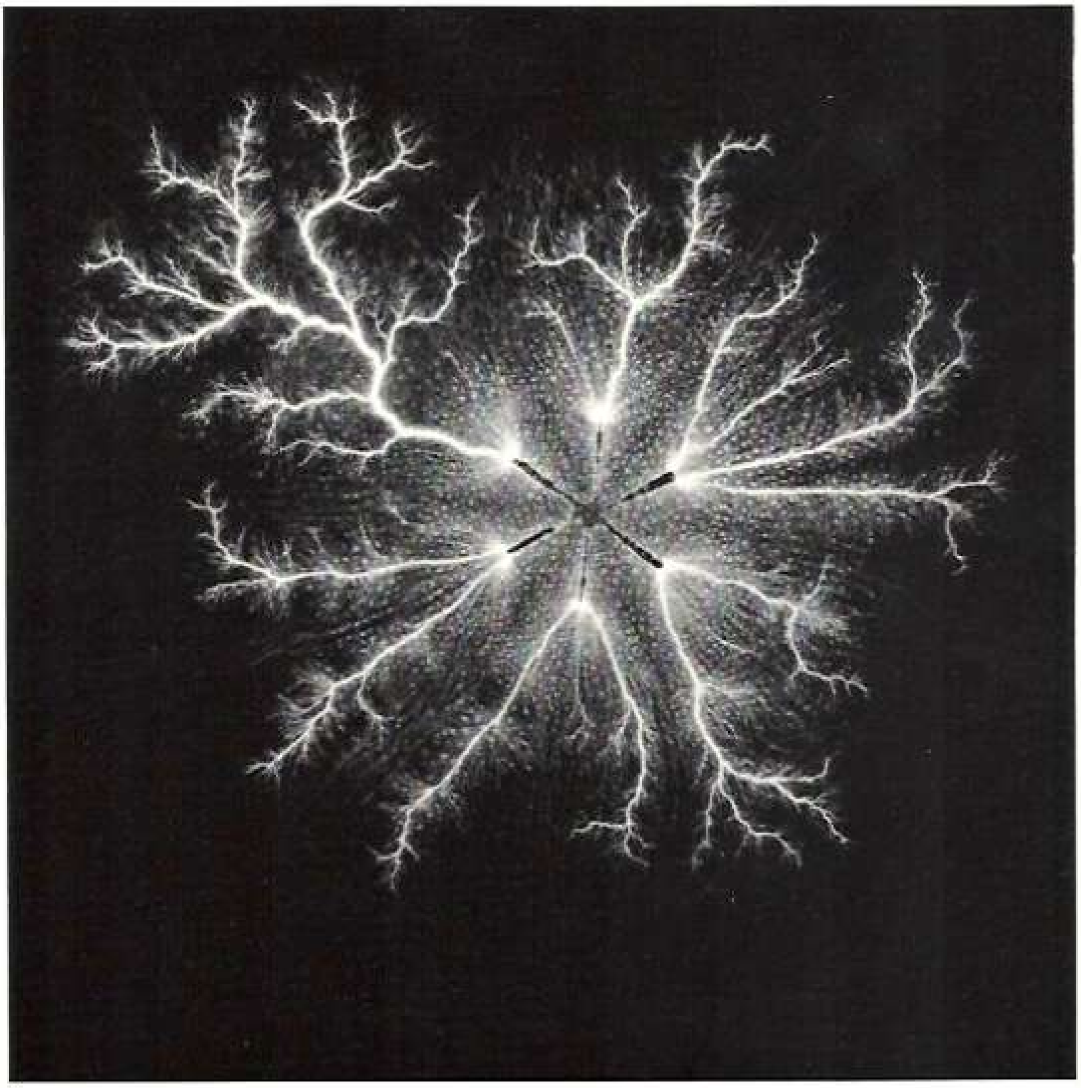
Constant concern with periodic and serial phenomena gives the eye a certain expertise. Everywhere it discerns repetitions and regularity or tendencies to these qualities. And at every turn one encounters quasi-periodic and quasi-serial formations and sequences of events. However, such features of regularity need not involve any real vibrational field. In "Cymatics 67" (p.113 ff.) we drew attention to periodic processes in which vibration in the true sense plays no part. Rhythmic precipitation (Liesegang rings), dehiscence of plastic masses, and diffusion in fluids were described. Phenomena coming under this heading occur in large numbers. Electric leakage discharges and discharge paths play a similar role. It must always be remembered in this connection that wave processes may also occur at the same time as, for example, in the rupture of solids, in the penetration of bodies by shot, and the explosive deformation of bodies, in all of which typical fracture forms and rupture contours appear. But quite apart from such simultaneous wave phenomena, cases like these also show a typical tendency for discontinuities to recur and for a pattern of regularity to appear even in the absence of a proper vibrational field. The familiar Lichtenberg figures (Figs. 61 to 63) are a further example of this kind. Normally they are formed by leakage discharges imprinting themselves direct in the photographic layer. The question of interest here is: How does such an electric discharge take place? What determines the actual pathways it follows? It is at once apparent from the figures that the electricity does not travel like an ordinary flash; instead we are struck by the way in which the elements are regularly repeated in the figures. One shoot comes after another, branch follows branch. What we have is a true dendritic pattern. There is a certain tendency to repetition at intervals although the figures do not display any periodic or harmonic pattern. Apart from this the discharge involves electrical wave processes and serial current impulses. Although neither periodicity nor harmonics are in evidence, the figured elements are shaped in such a way that polar situations are repeated. Trees, bushes and tufts are characteristic of the whole picture. The same key pattern can be traced down to the finely marked detail. The granulations and spots which have imprinted themselves on the film (mainly in Fig. 63) are very regularly arranged. The point to note about these well-known Lichtenberg figures is that their morphology is characterized by the regularity of the discontinuities and thus by the tendency of their elements to be repetitive. They serve to draw attention to one of Nature's most pervasive phenomena which might be formulated in some such terms as these: even without vibration in the narrow sense of the word



61

62

61, 62, 63
Here we see Lichtenberg figures (electric leakage discharges). These patterns are produced by the familiar method of allowing the electric discharge to imprint itself direct onto the photographic film. There is a clearly marked repetition in the morphology of these current paths where ray is followed by ray, and branch by branch, etc. A kind of serial arrangement appears in the discontinuities in which no actual vibration is involved. (The discharge took place at about 15 kV, natural size.)



63