Vol. V No. 4

The Angle Orthodontist

October, 1935

A magazine established by the co-workers of Edward H. Angle, in his memory. . . . . . .

Biologic Orthodontic Therapy and Reality

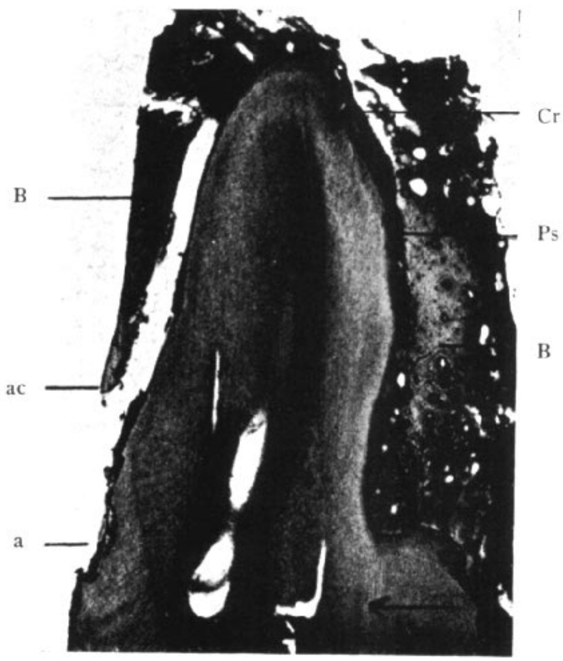
Professor Dr. Albin Oppenheim
Vienna, Austria

(Continued from Vol. V, No. 3)

Specimen VIII 4. This patient was sixteen years old. The appliance used was an unsupported, lingual spring, directed distally. This spring was 0.50 mm. in diameter, with a total length of 22 mm. The distally directed part was 8 mm. long. There was 1 mm. tension. Treatment was started on November 17, 1932. The spring was newly adjusted on December 9 and the extraction was made on January 29, 1933. *The whole time of treatment was seventy-three days, ten and one-half weeks of continuous force.* Unfortunately this important specimen does not give details as it was very much injured during the extraction and, in addition, was still more damaged by too long decalcification. Therefore, only the most remarkable but yet distinctly ascertainable injuries, which certainly must be blamed to the treatment, are pointed out.

The force worked in the direction of the arrow, (Fig. 36). In the area of the original alveolar crest a great cementum resorption is to be seen which, in the lower part, reaches deep into the dentin, (a, Fig. 36). This is reproduced in higher magnification in Fig. 37. In the depth of the lesion we see the marks of active resorption, i.e., cementoclasts, (cK, Fig. 37). The length of the resorption is 2 mm., which is a fifth of the total root-length of 9.6 mm. The alveolar crest, (ac, Fig. 36), has disappeared from the pressure of the tooth and reaches the upper part of the resorption as indicated by the bone particle, (B, Fig. 37). It is a justified supposition that a large part of the alveolar crest has been resorbed by a most intensive resorption from the periodontal side, for such an active stage of resorption as is present in Fig.

38, (high magnification of the part "ac" of a neighboring slide to Fig. 36), has hitherto not been ascertained. The contour of the bone alongside of its entire inner wall, is formed by numerous resorption lacunae, (R1, Fig. 38), at the bottom of which, however, no indication of osteoclasts apparently exists. The periodontium is missing, yet we see in all lacunae, everywhere, detritus which is probably the residue of the crushed and necrotic periodontium. The pediodontium which still clings to the tooth, (Pf, Fig. 38), does not at all show a functional structure. The poor capacity of staining of the cells certainly



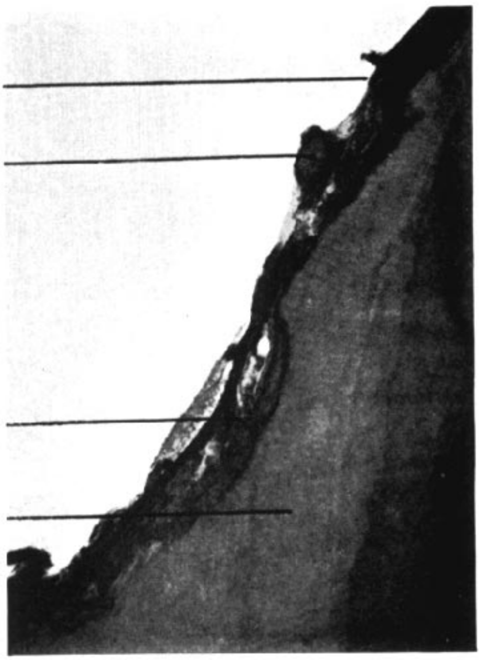
Specimen VIII (Figs. 36 to 38) Figure 36
Magnification 10; direction of movement is indicated by the arrow; B, bone; Ps, periodontal space; ac, alveolar crest; a, cementumresorption; Cr, cementumresorption at the apex.

is not to be attributed alone to their death, but also, for the most part, to the slow decalcification. At the periosteal outer side of the bone there is no trace of a repairing thickening (osteophyt). The statement of the nonappearance of the osteophytic bone apposition is justified because, at Per, Fig. 38, we still see a part of the periosteum adhering to the outer surface of the bone, beneath which the formation of osteophyts should have taken place.

Therefore, it is not to be assumed that such a deposition, once formed on the quite smooth bone surface beneath this point, was destroyed, mechanically, at the removal of the specimen.

As a result of the tilting of the tooth we find in the corresponding apex sphere, (Cr, Fig. 36), a deep-reaching resorption but not very extensive on the surface. It cannot be ascertained in this specimen whether there occurred a formation of an "angioma."

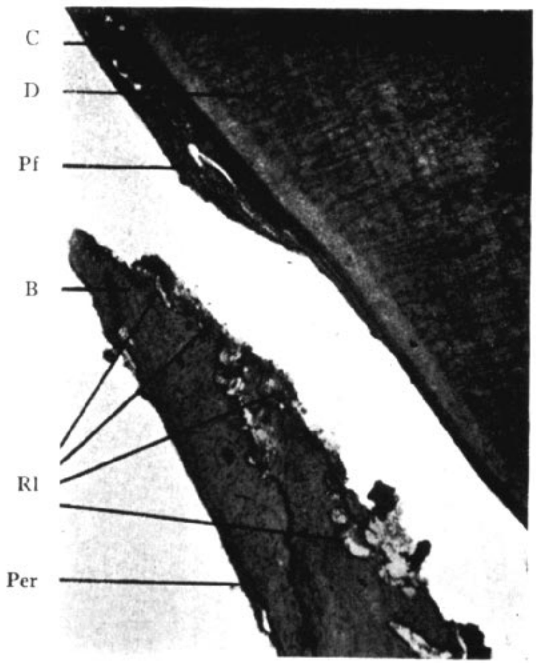
As far as can be seen in several slides, the changes within the pulp consist principally of a fibrillar degeneration of the stroma and a disappearance of odontoblasts by an insertion of vacuoles.



Specimen VIII (Figs. 36 to 38) Figure 37
Point "a" of Fig. 36; magnification 48; D, dentin; C, cementum; Cr, cementumresorption; cK, cementoclasts; B, bone particle.

Specimen IX 4: Girl of sixteen. The appliance used was a finger-spring soldered to an Angle expansion arch. This spring was 0.50 mm. thick, 8 mm. long and exerted 2 mm. tension in a lingual direction. Treatment was started June 8, 1932. After thirty days—four and one-half weeks of continuous force—retention was made by a lingual wire connection with the bicuspid of the other side. On July 6, 1932, after eleven weeks, the retention was removed (September 20, 1932) and during the next four and one-half months the tooth was given an opportunity to relapse to its original position. Extraction was performed on January 8, 1933. *The entire time of treatment was thirty days—four and one-half weeks of continuous force.*

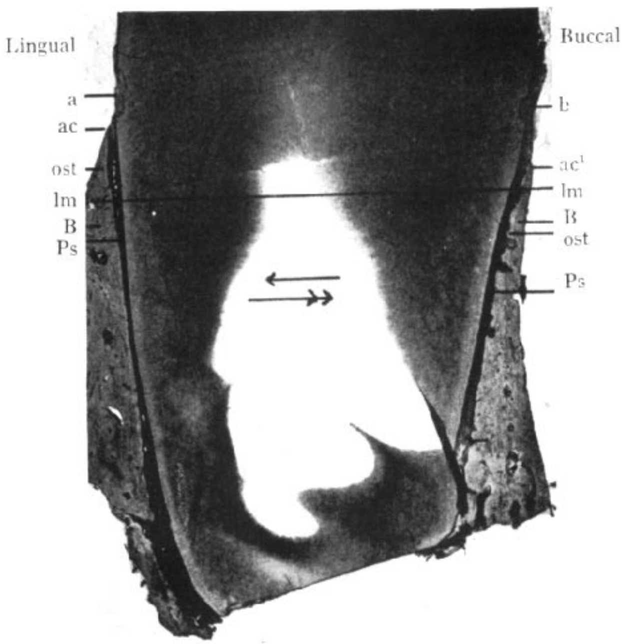
According to the described modus procedendi we find only the residues of the movement, i.e., pictures of a far advanced stage of repair. There are also pictures resulting from the self-movement of the tooth under the influence of occlusal forces when, after having been released from the retention,



Specimen VII (Fig. 36 to 38) Figure 38
Point "ac" of Fig. 36, from a neighboring slide; magnification 55; D, dentin; C, cementum; Pf, periodontal fibres; B, bone; R1 lacunae of resorption; Per, remnants of periosteum.

it goes back to its original position—as it "relapses." The primary movement, before applying the retention device, followed the direction of the simple arrow, (Fig. 39), toward the lingual. In the sphere of the original lingual *alveolar crest* (ac) which has disappeared under the effect of pressure, we find the corresponding cementum resorption which, only for the sake of a better understanding and in order to avoid constant repetitions, we shall designate as the "primary" resorption, (a, Fig. 39).

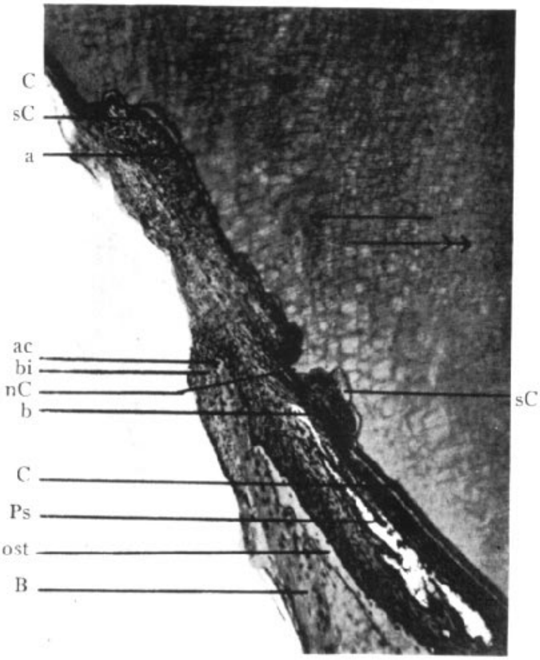
Just opposite, corresponding to the former buccal alveolar crest, we find a second resorption in the cementum, (b, Fig. 39). The buccal alveolar crest has also disappeared. To what extent this disappearance of the alveolar crest and the formation of the cementum resorption area occurred during the primary tooth movement as a result of jiggling, cannot, of course, be ascertained. The alveolar crest lies below the resorption "b," (ac^1, Fig. 39), which it has produced and which, with the above mentioned possibility,



Specimen IX (Figs. 39 to 49) Figure 39
Magnification 11; direction of active movement is indicated by the single arrow; direction of relapse movement by the double arrow. On the left is the lingual side; ac lingual, ac^1, buccal alveolar crest; B, bone; ost, osteoid; Ps, periodontal space; a and b, cement-resorptions; lm, line of measure.

developed during the relapse movement of the tooth. This resorption we will designate as the "secondary" resorption. The "primary" resorption "a," produced by the orthodontic movement, will always correspond to the "primary" resorption a^1 in the apex sphere, while the "secondary" resorption "b" will, in turn, always correspond to the "secondary" resorption b^1 in the apex sphere.

A high magnification of the "primary" cementum resorption "a" of Fig. 39, which was taken from a neighboring slide, is shown in Fig. 40. Here we see a second completely developed cementum resorption situated nearer to the apex and also indicated in Fig. 39. This is separated from the larger resorption by a narrow bridge of intact cementum, (nC, Fig. 40). The lingual alveolar crest (ac) is still reaching above this cementum isle up to the higher, large resorption, but, by a continuation of the movement, this cementum isle and the present alveolar crest would have been destroyed by further resorption in a very short time. The disappearance of the alveolar

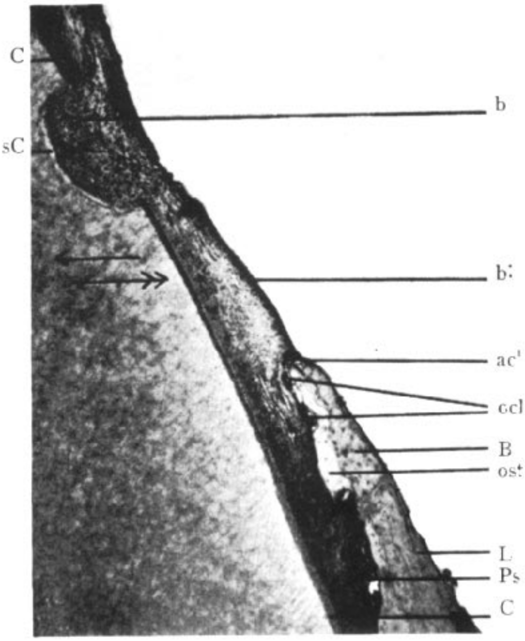


Specimen IX (Figs. 39 to 49) Figure 40
Point "a" of Figure 39; magnification 80; direction of active movement is indicated by the single arrow; direction of relapse movement by the double arrow. B, bone; ac, alveolar crest; ost, osteoid; Ps, periodontal space; C, cementum; nC, isle of normal cementum between the two resorptions a and b; sC, secondary cementum; bi, fibres of connective tissue between bone and tooth.

crest has certainly happened by the pressure, as is proved by numerous sections of this series in which the periosteal fibrillar fibers of connective tissue between the periosteal surface of the bone and the cementum are still intact. This connection, although injured, is to be seen at bi, Fig. 40.

On the buccal side in Fig. 41, a high magnification of the sphere b, Fig. 39, this ligamental connection is uninjured and distinct, (bi, Fig. 41). In the course of the series, the alveolar crest, as in all other examined teeth, does not display a regular circular disappearance but high intact areas of the crest alternate frequently with deep-reaching defects.

The remaining compact bone of the lingual alveolar wall, (B, Fig. 40), shows, on its inner side, the lacunar line of resorption along which, during the orthodontic lingual movement, resorption had taken place and on which, during the relapse movement of the tooth (double arrow), after removal of the retention, deposition of osteoid bone, (ost, Fig. 40), followed in the form

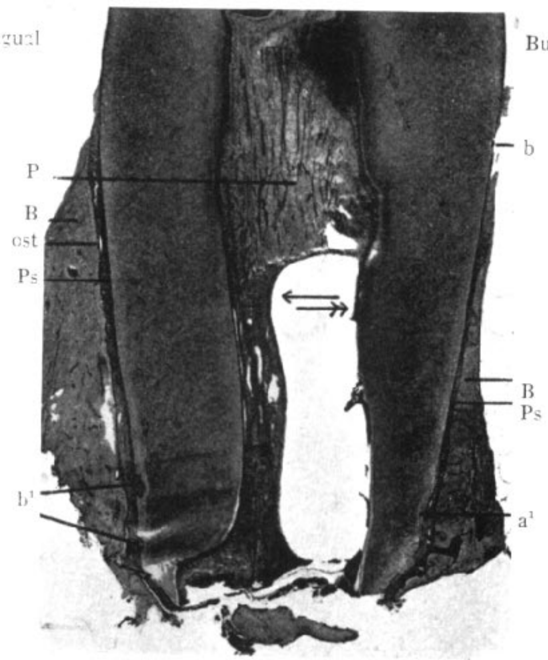


Specimen IX (Figs. 39 to 49) Figure 41

Point "b" of Fig. 39; magnification 70; direction of active movement is indicated by the single arrow; direction of relapse movement by the double arrow. B, bone, ac^1, alveolar crest; ost, osteoid; ocl, osteoclasts; C, cementum; b, cementumresorption produced during the relapse movement; sC, secondary cementum; Ps, periodontal space; L, lines of arrest in the bone (Haltelinie according to Ebner); bi, fibres of connective tissue between bone and tooth.

of a plane-like surface. The same can be noticed in Figs. 39 and 42 (ost), from the alveolar crest almost up to the middle of the root.

On the buccal side, the alveolar crest, (ac^1, Fig. 41), which certainly (because of the reasons given below) has disappeared intravital, lies a considerable distance below the deep but not very extended resorption "b" of Fig. 41, (a high magnification of b, Fig. 39). This resorption was caused, during the relapse movement, by the pressure of the tooth against the alveolar crest which originally, at least, must have been situated at the same level. On the side facing the tooth, the compacta of the buccal alveolar wall, (B, Fig. 41), is covered with a regular, thick layer of osteoid, (ost, Fig. 41), which is also to be ascertained, distinctly, in Fig. 39 and can be followed very far rootward. This osteoid developed during the original orthodontic lingual movement (simple arrow) and is brought to a stage of resorption now by the



Specimen IX (Figs. 39 to 49) Figure 42
Magnification 11; direction of active movement is indicated by the single arrow; direction of relapse movement by the double arrow. B, bone; ost, osteoid; Ps, periodontal space; a[1], cementumresorption near the apex corresponding to the primary cementumresorption "a" of Fig. 39; this has disappeared in this section; b[1], cementumresorption corresponding to "b," formed during the relapse movement; P, pulp.

relapse movement of the tooth (double arrow). In the resorption-lacunae, which are reaching toward the middle of the root, Fig. 39, there are still numerous osteoclasts, (ocl, Fig. 41). This osteoid has become resorbed without interfering with the integrity of the cementum (C). We described the same finding in Specimen VI, Fig. 24, where, also, by the self-movement of the tooth and the pressure against the osteoid, this became resorbed without damaging the cementum at all. The relapse movement in Specimen IX, Fig. 39, therefore must be considered as biological, though supported, or at least hastened, by occlusal forces.

We cannot recognize periosteal bone-depositions (osteophyt) on the original lingual pressure side, (Fig. 39 on the left), nor are there any indications on the buccal side during the relapse movement. The thinning of the alveolar walls from the periodontal side receives no compensation by periosteal bone deposition. The three (in the histological picture) blue lines of arrested growth in the buccal alveolar bone, (L, Fig. 41), and particularly the one that is situated most buccally, are to be considered as the expression of three periods of rest in the bone reconstruction, (Haltelinie, Ebner), rather than an an osteophytic deposition.

Continuing the series, the *cementum resorptions* at the lingual and buccal alveolar crests, one small resorption excepted, (b, Fig. 42), disappear from the horizon. In later sections these two resorptions reappear irregularly, sometimes showing the lingual and then, again, the buccal resorption more developed, giving the impression of a circular resorption for longer stretches, interrupted by intact cementum isles.

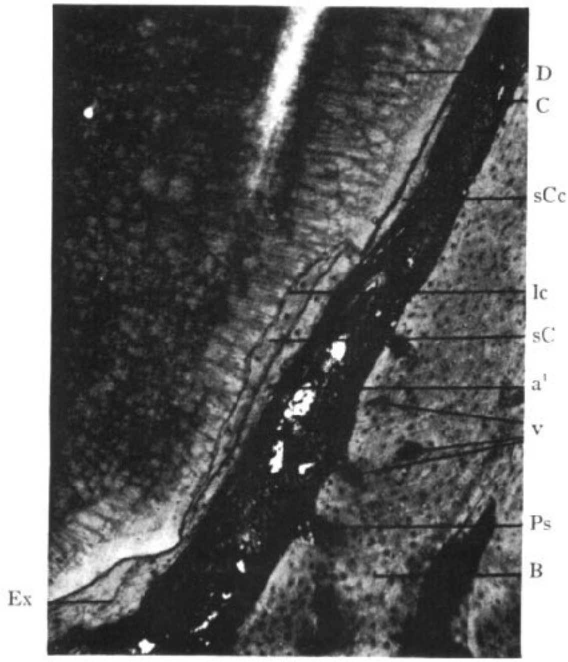
But the approximal root-surfaces, also, are not spared by resorptions, should the labial or lingual movements deviate to mesial or distal directions, as we can ascertain in numerous sections where, at the surgical removal, the approximal surface remained intact.

Corresponding to the two resorptions, the "primary" a and the "secondary" b, in Fig. 39 at the alveolar crest, are the resorptions in the apical region, the "primary" a^1 and the "secondary" b^1 of Fig. 42.* The "primary" resorption in the apical region, (a^1, Fig. 42), is in the whole series of slides and corresponds to the more developed primary resorption a, being more voluminous and deeper than the "secondary" resorption b^1, Fig. 42. The "primary" apical resorption, (a^1 of Fig. 42), is magnified in Fig. 43. The "secondary" apical resorption, (b^1, Fig. 42), is reproduced in high magnification in Fig. 44. The latter consists of two resorptions separated by intact cementum.

The natural length of the primary apical resorption, (a^1, Fig. 42), is 1.8 mm., and seems to be larger, for the root-point is not in the specimen. With a total root-length of 9 mm. (measured at the uninjured root-wall), the cementum occupies exactly one-fifth of the root-length.

*For the first time, we also see in this specimen resorptions in the cementum on the original traction side, which hitherto have been denied by special remarks.

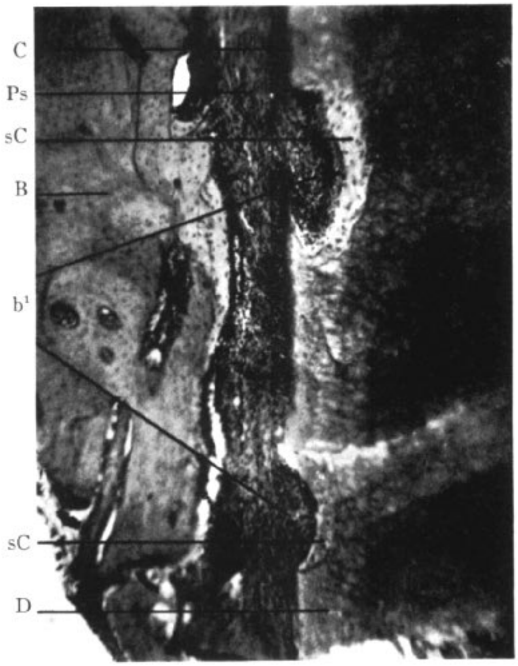
The course of repair in the cementum resorptions a and a[1], as well as in b and b[1], appertaining to each other, point to a different time of origin. The "primary" resorption a, Fig. 40 and the appertaining one, a[1], Fig. 43, exhibit a much farther advanced stage of repair than do the "secondary" resorption b, Fig. 41, and the appertaining resorption b[1], Fig. 44. The deposition of secondary cementum (sC) in the primary resorptions a, Fig. 40 and a[1], Fig. 43, is much more progressed. This is especially noticeable in the cementum resorption at the apex, (a[1], Fig. 43), in the base of which the secondary cementum had been deposited on the lacunar bordered surface



Specimen IX (Figs. 39 to 49) Figure 43
Point a[1] of Fig. 42; magnification 40; bone; Ps, periodontal space; v, vessels in the bone; C, cementum; a[1], cementumresorption formed during the active movement; lc, lacunary bordered surface of dentin, on which the secondary cementum (sC) was deposited in two distinct layers; sCc, the exaggeratedly formed secondary cementum overlying the primary cementum (C); Ex, cementumexostosis.

of the dentin, (lc, Fig. 43), quite distinctly in two layers. By this process the defect was filled up entirely. Moreover, the deposition of secondary cementum happened in excessive exaggeration and has resulted partly in the formation of exostosis, (Ex, Fig. 43), and partly in a deposition which is overlying the primary cementum, C, for a long stretch, (sCc, Fig. 43). The compact bone, (B, Fig. 43), lying opposite, displays a perfectly smooth surface which has no more marks of the resorption which took place during the orthodontic movement, but it is very likely that the numerous inclosed vessel-channels, (v, Fig. 43), represent the result of the reconstruction.

The relapse movement of the tooth, enforced by occlusion, has produced the secondary resorption, b, Fig. 39, (magn. in Fig. 41), and the appertaining resorption at the apex-sphere, b^1, Fig. 42, (magn. in Fig. 44). These started to develop eleven weeks later, after removal of the retention and are, therefore, of a more recent date (eleven weeks younger). Because of this, the

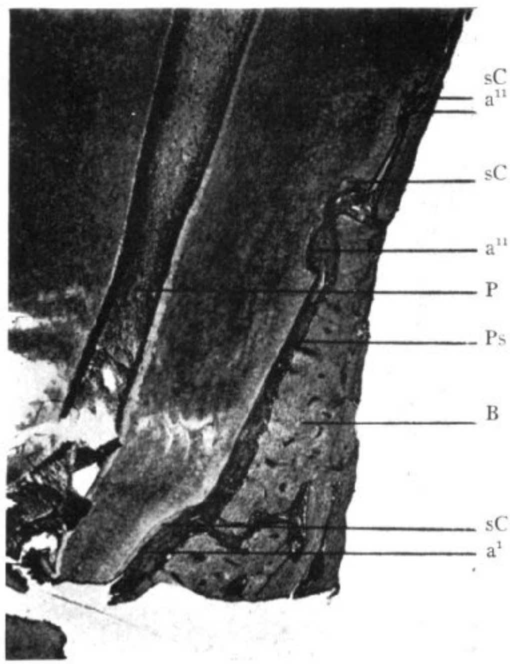


Specimen IX (Figs. 39 to 49) Figure 44
Point b^1 of Fig. 42; magnification 60; b^1, secondary cementumresorptions near the apex, corresponding to the cementumresorption b of Fig. 42, being of recent age; the apposition of secondary cementum (sC) is much less than in the resorption a^1 of Fig. 43; B, bone; C, cementum; Ps, periodontal space; D, dentin.

progress of healing is less advanced. It is true that we also find, in these resorptions, secondary cementum, (sC, Figs. 41 and 44), but the remainder of the defects are filled up with quite young connective tissue, rich in cells.

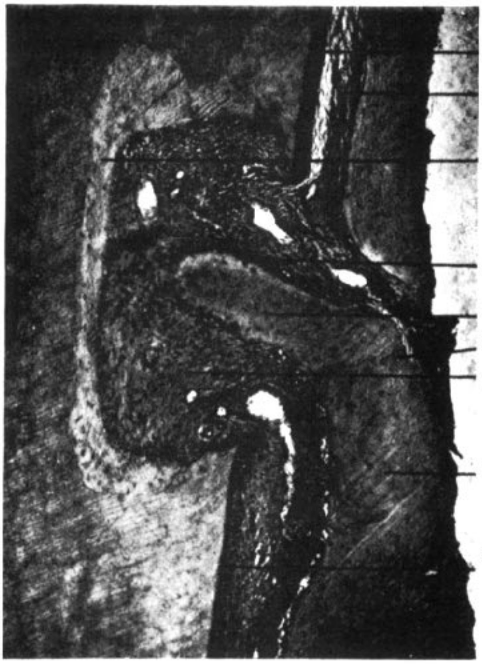
Continuing through the series we observe, besides the extended "primary" resorption in the apical cementum, (a^1, Fig. 45), for the first time in this series, two other resorptions from the same cause and in the same period, (a^{11}, Fig. 45), and therefore also in the same healing stage, (sC, Fig. 45).

We are already familiar with the generally known fact that nature makes every effort to narrow to an adequately normal width, as quickly as possible, the periodontal space if, by some reason, it has enlarged too much. In addition to filling this space by the normal process of osteoid formation the result can be accelerated by a forward vaulting of the bone towards the surface-like extended defects of the tooth, (Specimen IV, Figs. 13 and 15 and Specimen VI, Fig. 25), or by a hypertrophic cementum formation, (Ex, Fig. 43).



Specimen IX (Figs. 39 to 49) Figure 45
Magnification 22; pressure side near the apex, during the active movement; crown movement is indicated by arrow; there are to be seen three comentumresorptions (a^1, a^{11}); B, bone; Ps, periodontal space; sC, secondary cementum; P, pulp.

Nature's endeavors to eliminate a too wide periodontal space, taking into account the given conditions, are sometimes performed in quite a peculiar way, as is to be seen in Fig. 46, a magnification of a^{11} of Fig. 45, from a neighboring slide. We see a bone-projection pushing forward into the narrow entrance of a deep resorption. This is distinctly to be recognized as newly formed bone, (ost, Fig. 46), contrasting with the old bone, B, and separated from it by a sharp border-line, ld. This projection of the newly-built bone is framed by osteoid, closely beset with osteoblasts, (obl, Fig. 46). This bone-projection is already in closest connection with the thick layers of apposed secondary cementum, (sC, Fig. 46). The hollow space is nearly transformed to a normally functioning periodontal space. It is possible, on account of the progressive apposition of secondary cementum and the diminishing of the depth, that this bone-projection is becoming gradually smaller and perhaps will disappear entirely.



Specimen IX (Figs. 39 to 49) Figure 46
Region a[11] of Fig. 45 from a neighboring slide; magnification 85; B, bone; ost, projection of newly formed bone into the cementumresorption; ld, demarcation line between old bone and osteoid, which is beset by a dense osteoblastic layer (obl); C, cementum; sC, secondary cementum; Ps, periodontal space; pf, periodontal fibres already inserted into secondary cementum and osteoid.

The natural depth of the resorption is 0.38 mm. which, with the total thickness of 1.28 mm. for the root-wall, corresponds to about one-third of the wall measure! And that already after four and one-half weeks of continuous force!

To complete the changing picture on the root surface, two further slides may be shown. One of them, Fig. 47, contains in its lower part, four "primary" cementum resorptions in an advanced healing stage, (a^1, Fig. 47), the uppermost of them corresponding to that shown in Fig. 46. However, in that part of the root it is more plane-like and of lesser depth and the pivot-like bone-projection is reduced to a convex vaulting of the bone. The cementum resorption reappearing in the upper part of the slide, (b, Fig. 47),

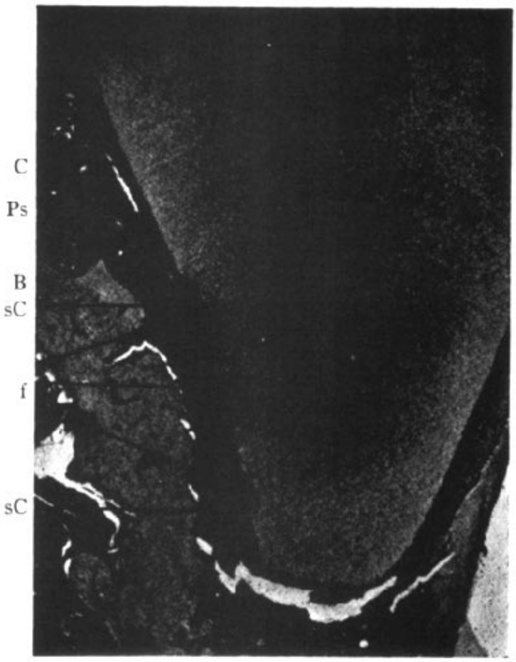
Specimen IX (Figs. 39 to 49) Figure 47
Another slide in the course of the series; magnification 11; direction of active movement is indicated by the single arrow; direction of relapse movement by the double arrow; B, bone; Ps, periodontal space; a^1, four cementumresorptions occurring during the active movement; C, cementumresorption near the alveolar crest, occurring during the relapse movement, reappearing again.

corresponds to the already shown secondary resorptions, b, in former pictures which, during the relapse movement of the tooth (double arrow), had developed. The corresponding "secondary" resorptions, b^1, in the apex-sphere that were caused during the tilting relapse movement of the tooth were shown previously in Figs. 42 and 44.

In Fig. 48 we find three resorptions lying on the approximal surface, due to deviation of the direction of force. The origin and localization are clearly explained on the reconstruction model.

The tissues of the *periodontal space* do not yet reveal quite normal conditions as to the course of the fibers and the richness in vessels. The relapse movement of the tooth is not yet finished and is distinctly revealed by the resorption on the inside of the buccal alveolar crest, (ocl. Fig. 41).

There is no angioma-like buffer formation as, probably, the increase of



Specimen IX (Figs. 39 to 49) Figure 48
Another slide in the course of the series, already at their end, within the bifurcation; magnification 25; the three cementumresorptions, f, are produced by the deviation of the direction of the force; B, bone; Ps, periodontal space; C, cementum; sC, secondary cementum.

the pressure at the relapse movement did not reach a degree which made protective measures necessary. In spite of enforcement by occlusion, the movement is to be considered as a biological one. Proofs of it are the missing of the "buffers," the intact cementum, the equal width of the periodontal space on the pressure and traction side, which is 0.13 mm. at the measure-line, (lm, Fig. 39), and the normal course of the fibers in numerous places.

The time lies too far back to state anything about formation or absence of buffers during the orthodontic lingual movement, and in the meantime the lingual pressure side has become the traction side.

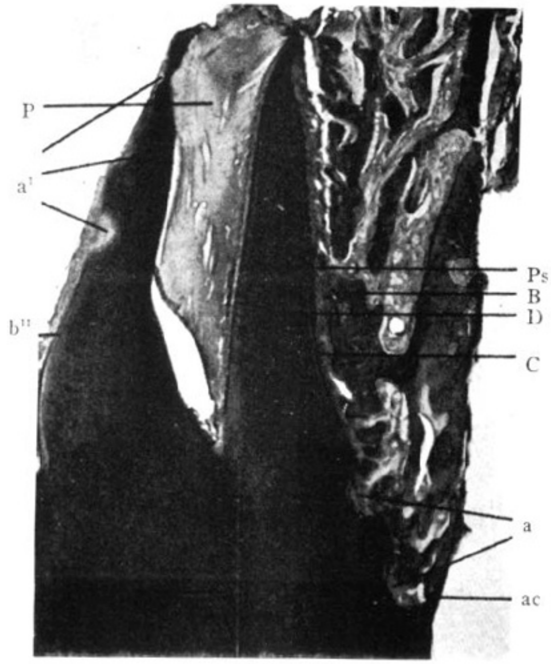
The crown-pulp, Fig. 49, a high magnification of part P, Fig. 42, does not at all offer a normal picture. Numerous engorged and enlarged vessels still dominate the whole sphere. A normal odontoblastic layer is only to be ascertained in the upper parts of the crown-pulp.

Specimen IX (Figs. 39 to 49) Figure 49

Point P of Fig. 42; magnification about 50; v. vessels; n, nerve bundles.

Specimen X 4: Girl of thirteen. The appliance used was the lingual arch, a loop-spring of 0.40 mm. wire, length 25.5 mm. The tension was 1½ mm. Treatment was started November 24, 1931. Force was renewed 1½ mm., after four weeks. The whole measure of movement was about 3 mm. Extraction was performed on February 16, 1932. *The whole time of treatment was eighty-four days—twelve weeks of continuous force.*

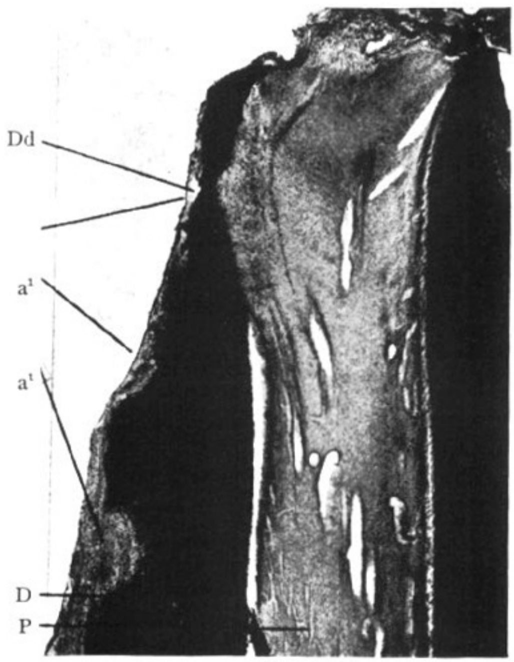
In Fig. 50 we find an outline-picture of the buccal root of an upper bicuspid. The simple arrow indicates the direction of the orthodontic movement; the double arrow the direction of the back-movement (jiggling). Two resorptions, separated from each other by a bridge of intact cementum, have been established at the level of the alveolar crest, (a, Fig. 50). The upper one reaches deeper into the dentin. As in Specimen IX, these resorptions, produced by the orthodontic movement, will be figured as "primary," letter "a," and the corresponding resorptions, situated diametrically at the apex,



Specimen X (Figs. 50 to 59) Figure 50
Buccal root of upper bicuspid; magnification 14; direction of active movement is indicated by the single arrow; backward (jiggling) movement by the double arrow; B, bone; ac, alveolar crest; C, cementum; D, dentin; Ps, periodontal space; a, cementumresorptions; a^1, cementumresorptions at the apical sphere of pressure associated with resorptions "a" brought about by the active movement; b^{11}, cementumresorption in the height of the bifurcation, brought about during the backward movement; P, pulp.

will be marked a^1. The resorptions on the lingual side, caused by the backmovement, will be registered as "secondary" by the letter "b," and the appertaining resorptions in the apical sphere, as b^1.

The alveolar crest on the buccal pressure side, (ac, Fig. 50), reaches only to the middle of the lower cementum resorption. It has, therefore, disappeared a little. This part is shown in high magnification in Fig. 52, ac, alveolar crest. The disappearance has certainly occurred by the pressure, which is confirmed by the intact stage of the fibrous fibers between the periosteal surface of the lowest bony spicules and the cementum, (bi, Fig. 52). In spite of the influence of continuous force, the bone bears no signs of active reaction on its periodontal side, but symptoms of repair—small seams of osteoid bordered by osteoblastic rows or only the latter, (obl, Figs. 52 and

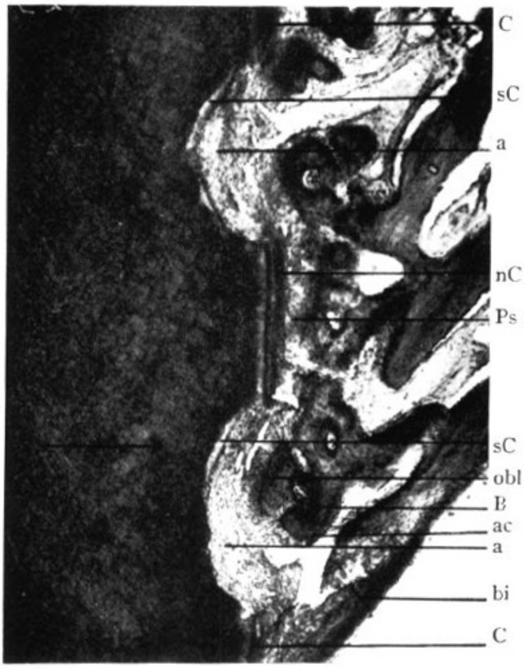


Specimen X (Figs. 50 to 59) Figure 51

Upper part of Fig. 50; magnification 30; D, dentin; P, pulp; a[1], cementumresorptions; Dd, quite thin dentin still separating the pulp from the periodontium.

53). It may be that the loop-spring became passive at the end of treatment or became active in another direction either by some change of the form of the main arch or by bending or slipping or by failure of the lock. At the places described as exposed to the first force of pressure, a state of "rest" or, better said, a state of repair is at any rate prevailing, while at other places, as we shall see, active resorptions have been brought about. The specimen does not show anywhere the active, expected, reaction of the force, but everywhere the consequences.

The two "primary" cementum resorptions corresponding to the alveolar crest, (a, Fig. 52), unite, in the further course of the series, in a very much extended, surface-like resorption, (a, Fig. 53), in which the former existing isle of intact cementum has been reduced, by resorption, to a very small remnant, (nC, Fig. 53).



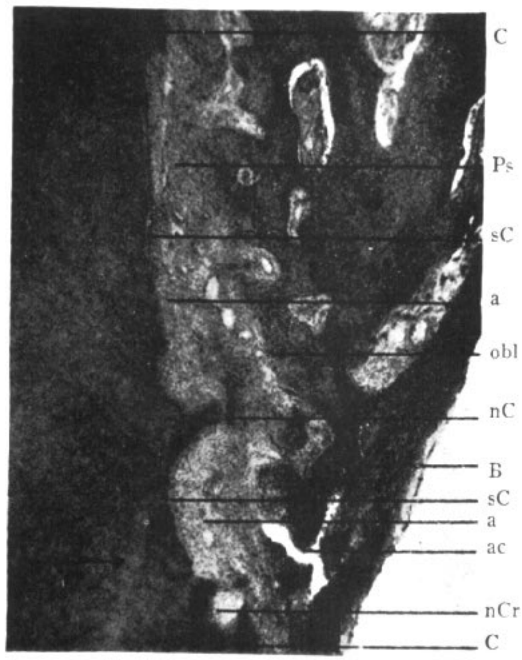
Specimen X (Figs. 50 to 59) Figure 52

Point "a" of Fig. 50; magnification 51; direction of movement during active treatment is indicated by the arrow; B, bone; ac, alveolar crest; obl, osteoblasts; Ps, periodontal space; C, cementum; a, cementumresorptions; sC, secondary cementum; nC, cementum isle between the two resorptions; bi, fibres of connective tissue between bone and tooth.

The length of the whole resorption-sphere, from normal-to-normal cementum, is 1.7 mm., which, by the given total of root-length of 9 mm., corresponds to a fifth.

On the base of the resorptions, as well as on the bone, we already see and for the same reason, the initial healing stage—formation of secondary cementum, (sC, Figs. 52 and 53), although we can still observe signs of active force-effect—the formation of a quite recent resorption into the dentin from the bottom of the lower cementum resorption, (nCr, Fig. 53), with some cementoclasts.

Such signs of still active reaction on the bone and cementum exist in numerous other slides of the series and justify the assumption that the force was deviated from some parts and became active in others.

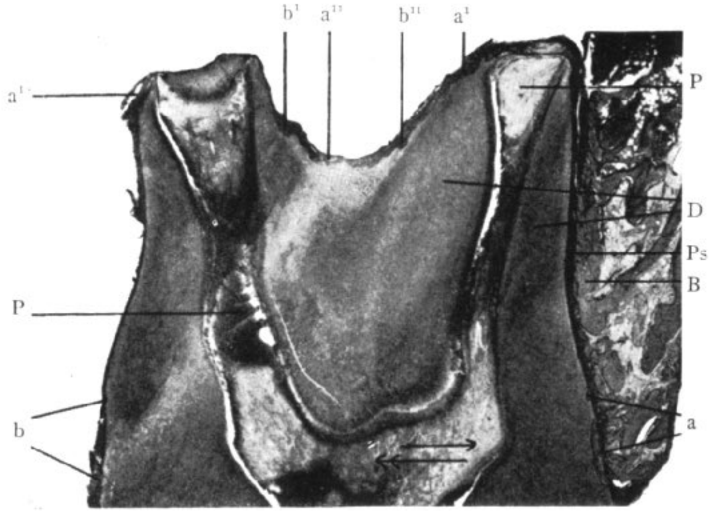


Specimen X (Figs. 50 to 59) Figure 53
Corresponds to Fig. 52 in the course of the series; magnification 55; direction of movement during active treatment is indicated by the arrow; B, bone; ac, alveolar crest; obl, osteoblasts; Ps, periodontal space; C, cementum; a, cementumresorptions; sC, secondary cementum; nC, cementum isle between the two resorptions; nCr, cementumresorption of quite recent date.

The outer picture of the cementum resorption constantly changes in the course of the series. The resorption "a," shown in Fig. 50, presents itself in a, Fig. 54, in quite another shape. In the case of the reproduction models, a clear explanation is offered for these varying pictures.

Tilting teeth with two roots create four pressure-points as shown in sketch Fig. 17.

Corresponding to the "primary" cementum resorption a, in Figs. 50 and 54, we find, at the diametrically opposite root-end, the "primary" cementum resorptions a^1, Figs. 50 and 54, to which a great part of the root has fallen a victim and which, in the most apically situated resorption lying near the root-end, has penetrated within a threatening proximity of the pulp, (a^1, Figs. 50 and 51). Also, in these resorptions, as well as in the intraradicular cementum, (a^1, Figs. 50, 54, 55 and 56), we still find some

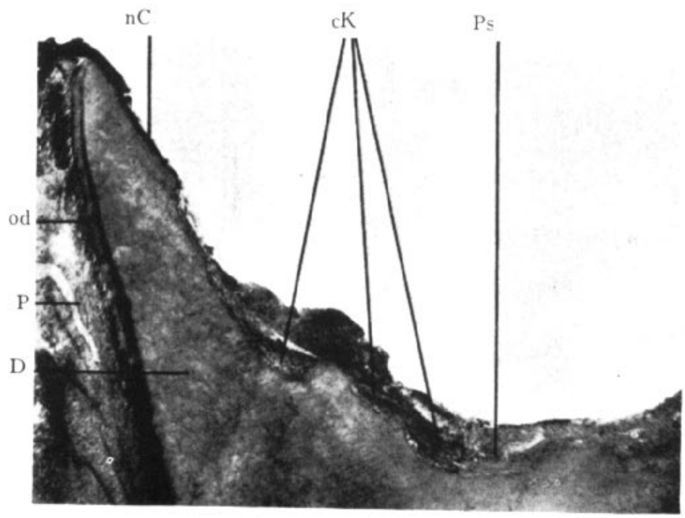


Specimen X (Figs. 50 to 59) Figure 54
Magnification 10; direction of movement during active treatment is indicated by the single arrow; direction of backward (jiggling) movement by the double arrow; B, bone; Ps, periodontal space; D, dentin; P, pulp; a, primary cementumresorptions brought about during active movement; b, secondary cementumresorptions brought about during backward movement; a^1 and b^1 correspond to the resorption a and b, respectively; a^{11} and b^{11} correspond to the resorption a and b, respectively, in the height of the intraradicular cementum and are established, according to Fig. 17, on the alternate points of pressure during the jiggling movement.

mono- and poly-nuclear cementoclasts. This indicates that these latter resorptions are in a perfectly active stage, while, as we have seen, in the resorptions at the alveolar crest, the repair stage comes into the foreground.

At the corresponding pressure-points on the lowest parts of the intraradicular cementum there are also the "primary" cementum resorptions, (a^{11}, Fig. 54), in an active stage. Through confluence with the secondary cementum resorptions, b^1, during the back-movement (double arrow), quite great resorptions, embracing the whole intra-radicular cementum, have formed.

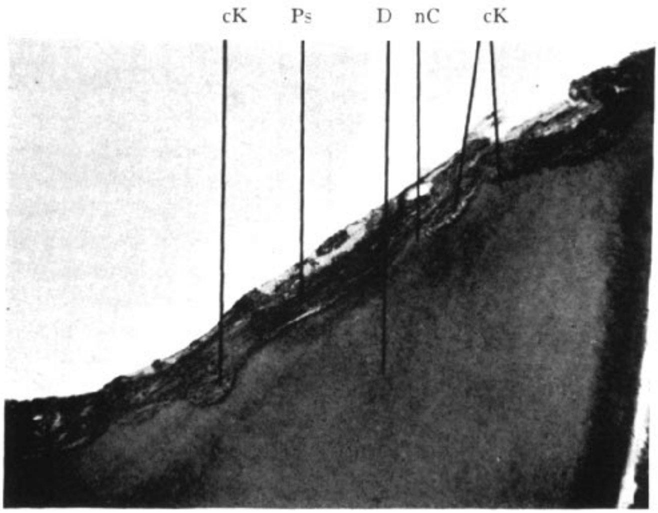
The "primary" resorptions, a and a^{11}, in the intra-radicular septum, and the "secondary" resorptions resulting from the back movement (double arrow), b and b^{11}, are shown in Fig. 54 and magnified in Figs. 55 and 56. In Figs. 54, 55 and 56, we see the whole intra-radicular septum and find there only two places of intact cementum, at nC, Figs. 55 and 56. The remaining cementum has fallen a victim to the resorption and the dentin is laid free, bordered by deep-reaching, wide resorptions. Everywhere in the lacunae are found cementoclasts, (cK, Figs. 55 and 56).



Specimen X (Figs. 50 to 59) Figure 55
Left portion of the intraradicular cementum of Fig. 54; magnification 50; nC, remnants of normal cementum; cK, cementoclasts; D, dentin; P, pulp; od, odontoblastic layer; Ps, remnants of the periodontal tissues.

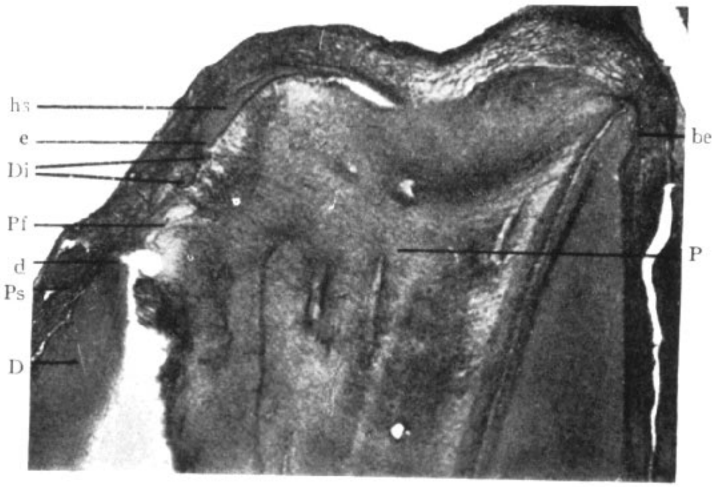
The ever recurrent, backward movement of the tooth towards its original position, from the forces of occlusion, has produced "secondary" resorptions at the corresponding pressure-points. This has also occurred at b, in Fig. 54, and in the septum at b and b^{11}, in Fig. 54, for not even the spring, which lies close to the tooth, can prevent the backward movement of the tooth as caused by the forces of occlusion. It is simply compressed.

In the use of strong forces on monkeys, a deviation of the apex in the opposite direction to that of the crown was once shown with simultaneous deviation of the nerve-vessel-bundle which enters the apex. (Int. Jour. Orthod. 1934, p. 23). Le Roy Johnson, Appleton and Rittershofer, too, proved a change of form as a consequence of strong forces, viz., a bending of the not yet fully calcified root-ends. Such a pathologic influence upon the insufficiently hardened root-ends with still open foramen apicale could be ascertained in this case, also. In Fig. 57 and 58 we see, on the left hand at "hs," how the Hertwig epithelial-sheath has been bent, while the outer wall of the open foramen exhibits a double bending, (be, Fig. 57). What extreme deviations can be produced by such bendings as a result of the further growing of the epithelial-sheath, is shown in Fig. 94, (Kronfeld's[18] Fig. 316).



Specimen X (Figs. 50 to 59) Figure 56
Right portion of the intraradicular cementum of Fig. 54; magnification 50; nC, remnants of normal cementum; cK, cementoclasts; D, dentin; Ps, remnants of the periodontal tissues.

Following, in the series, the uppermost cementum resorption previously noted in a^1, Fig. 51, which had penetrated already closely to the pulp, we perceive that the thin dentin layer, Dd, was not able to resist the advancing resorption. Thus, by the continuity of the force, there was established a perforation into the pulp, (Pf, Fig. 57). The lower border of the perforation is to be seen at "d," the upper border at "e." Between the two border-lines we find two dentin-isles still remaining. Di, Fig. 57, the upper one, is, as yet, in connection with the highest root-part by a narrow dentin bridge. This is shown magnified in Fig. 58. The dimension of the perforation from d to e showed a diameter of 0.58 mm. No words need be wasted on the great importance of the possibility of such a perforation in the use of continuous forces (of course a loop-spring!). Full scope is given to the premature degeneration of the pulp by the proliferation of the periodontal tissue and all other possible consequences, such as depositions of bone at the inner wall of the pulp cavum and formation of bone-specules in the pulp-stroma, which, eventually joining, finally lead to a perfect ossification of the pulp. The odontoblasts are either completely destroyed by the advancing foreign tissues intruding the pulp or only scanty remains of odontoblasts are still to be found.



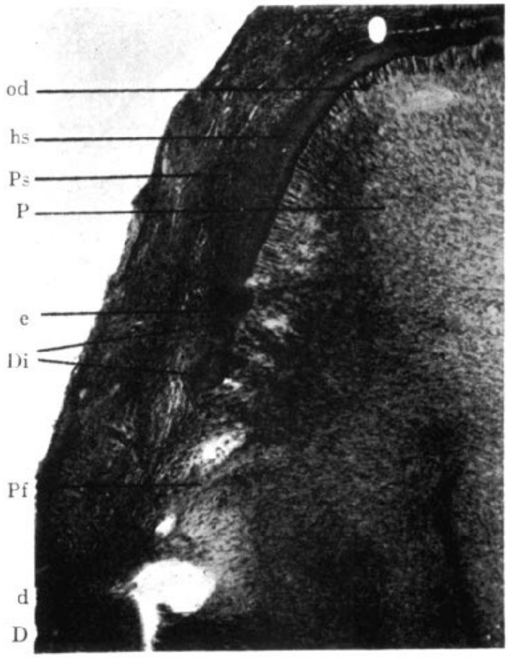
Specimen X (Figs. 50 to 59) Figure 57

The point Dd of Fig. 51 in the course of the series; magnification 40; Pf, perforation of the dentin and communication of pulp with the periodontal space; d and e, borders of the perforation; Di, isles of dentin within the perforation; hs, bending of the root end; be, double distortion of the root end; P, pulp; Ps remnants of the periodontal tissues.

The severe damage to the cementum observed in this case is out of proportion to the relatively insignificant marks of reaction on the part of the bone. These relatively heavier cementum injuries are also to be ascertained in Specimen IV, where intermittent elastic force was applied at comparatively long intervals. This tooth in Specimen IV was taken from the same patient and a special constitutional vulnerability of the cementum must be taken for granted. However, the fact that such happenings as just described can occur at all offers sufficient evidence that *the stereotyped application of certain measured forces cannot be considered as right or best suited for all cases.*

The *pulp,* Fig. 59, shows considerably increased and enlarged capillaries and veins with thickened walls, v, and also degeneration of the odontoblast rows for long stretches. The perforation must be of quite recent date, for the resulting changes are not yet developed to a high degree.

The following pictures illustrate cases from practice. In both of these cases it was impossible to provide sufficient room for the upper canines and also the necessary lingual movement together with the rotation of the front-teeth, so that after a treatment of two years and one and one-half years,

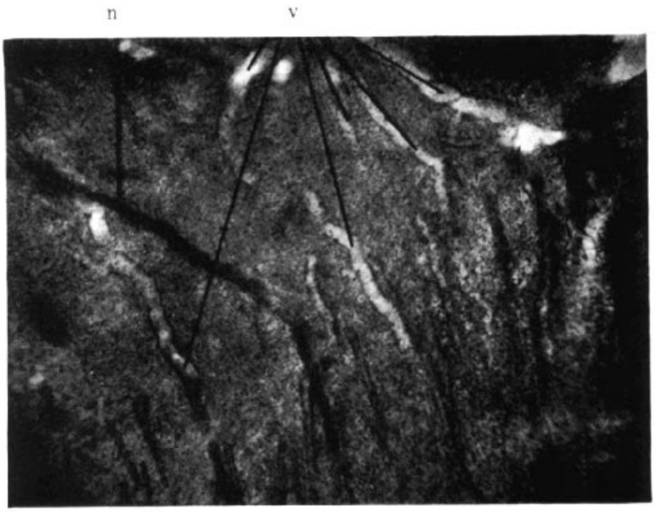


Specimen X (Figs. 50 to 59) Figure 58

Point Pf of Fig. 57; magnification 70; D, dentin; P, pulp; od, odontoblastic layer; Ps, periodontal tissue; Pf, perforation; d and e, lower and upper border of the perforation; Di, isles of dentin within the perforation, at e still connected by a small bridge of dentin with the topmost part of the root dentin (hs); bending of the root end.

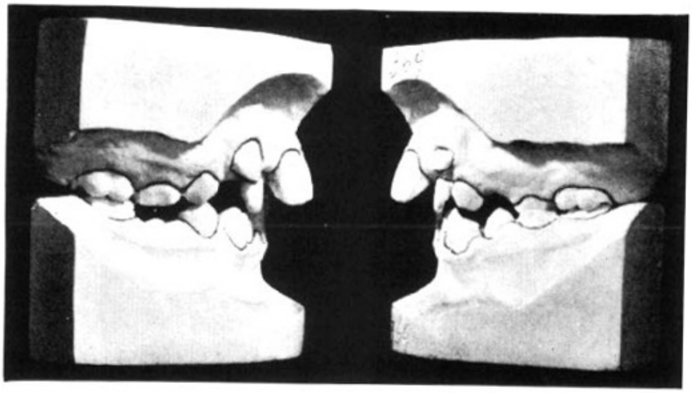
respectively, one had to decide on the extraction of the two upper first premolars. One case, (Figs. 60 to 74), had been treated almost up to the final stage with the lingual arch and loop-springs; the second, (Figs. 75 to 85), exclusively with the expansion arch, by one of my pupils.

In Fig. 60, I, we see the starting models (October, 1931) of the case, a Class II, Division 1 malocclusion, treated with the lingual arch. In II we see the stage after completed expansion and the gaining of normal mesio-distal relations. On account of the loosening of the molars, an expansion-arch was put on the second premolars (March, 1933) in order to obtain room for the canines and incisors in continuing further expansion. Because sufficient room could not be gained by this procedure (stage III; lack of space for the canines and lateral incisors) the two first premolars were extracted, (December, 1933).

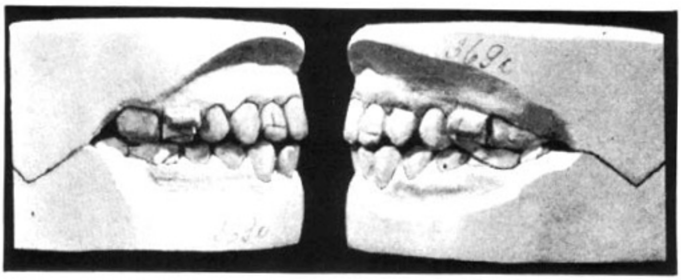


Specimen X (Figs. 50 to 59) Figure 59
Pulp; magnification 70; v, vessels; n, nerve bundles.

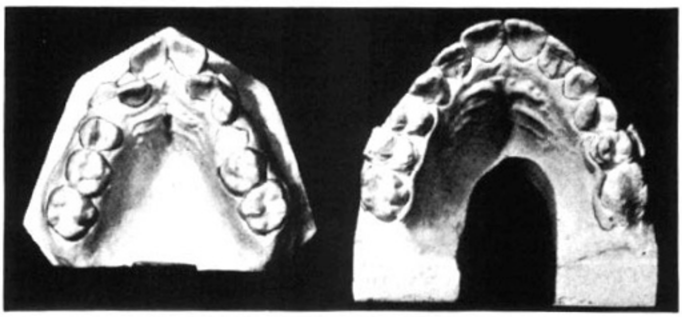
Acute caries in all teeth made the premature removal of the appliance imperative. The necessary hygiene of the mouth could not be forced during the whole treatment and the premature interruption of the treatment was also motivated by the deleterious state of the teeth, for which, because of the frequent but useless admonishments to the patient to care for the necessary mouth-hygiene, every responsibility was declined. Nothing can be reported on the present state of the denture which, after the extraction, had been left without any appliances. Following the extraction, which was performed one and one-half years ago, the patient, a girl of thirteen, appeared no more in my office.



I



II

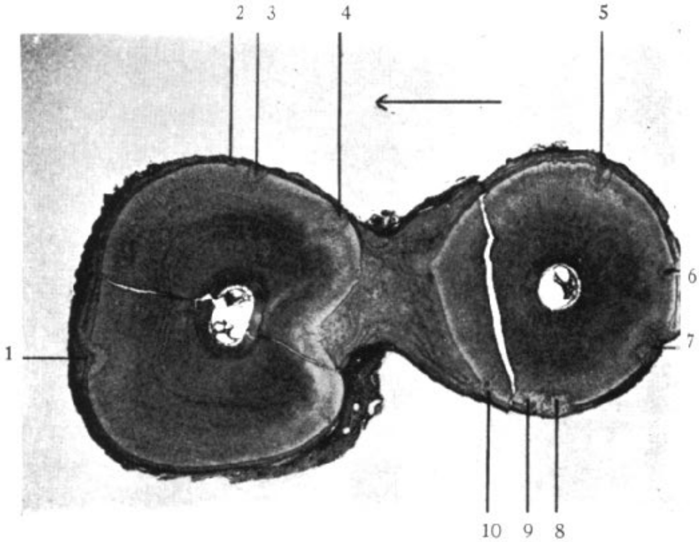


III

Specimen XI (Figs. 60 to 68) Figure 60

I, before treatment; II, after completion of expansion and establishing normal mesio-distal relations; III, occlusal view before and after expansion, just before the extraction of the *4/4*.

Specimen XI is the right premolar which was simply extracted without the surrounding bone. This was cut across from the apex to the crown for the examination. The slide in Fig. 61 shows, as a consequence of the jiggling movements in different directions, no less than ten partly flat and partly deeper reaching cementum-resorptions at the periphery of both the root-ends. They are in the state of repair for, with the application of the expansion arch, only intervals of weeks between the appointments were necessary and six weeks had passed since the last adjustment of the expansion arch till the extraction. The movement of the crown followed in the direction of the arrow. Corresponding to this primary movement, we find the resorptions



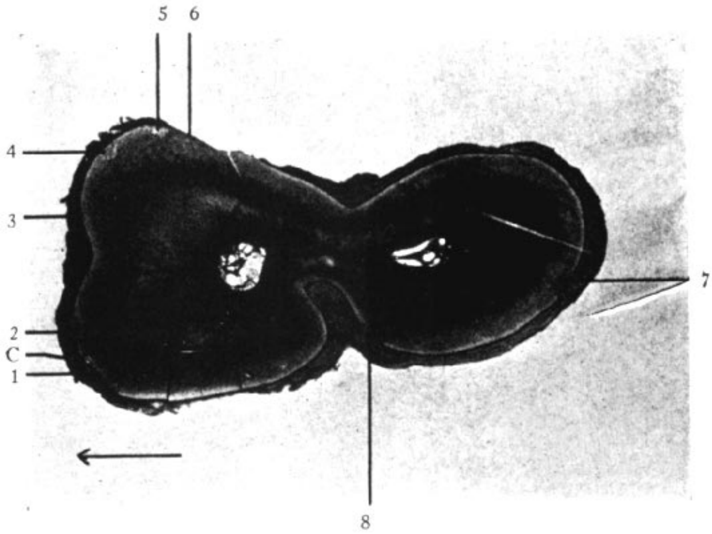
Specimen XI (Figs. 60 to 68) Figure 61

Magnification 20; for description see text.

at the diametrically apposed root-end, (4, 6 and 7, Fig. 61). By deviation of the force direction, mesiodistally, resorptions on the approximal surfaces had formed, (2, 3, 5, 8, 9 and 10, Fig. 61). By the backward movement of the crown toward the lingual, in the apical region, resorption 1 had developed.

In following the series further crownward, quite a different picture shows, (Fig. 62). Here, a little nearer to the crown, we find the effects of the primary force, the terminations of the heavy resorptions in the alveolar-sphere itself. The crown-movement followed the direction of the arrow and produced resorptions 1, 2, 3 and 4. A cementum isle between resorptions 1 and 2, (C, Fig. 62), has been left. Coincidentally with the crown-movement, resorption 7, Fig. 62, developed on the diametrically opposed side, visible almost up to the apex, and there, to an even greater extent, 7, Fig. 61. By a deviation of the force-direction, resorptions 5 and 8, Fig. 62, were produced on the approximal surfaces, like resorption 6, which in the low magnification that is shown, appears like an artificial defect, but in high magnification distinctly shows depositions of secondary cementum.

In Fig. 63, in the alveolarcrest-sphere of the root, we find a wound-surface already occupying the whole buccal plane (from a to b) and not interrupted by cementum isles. Its terminations we have seen in Fig. 62. Everywhere, in more or less thick layers, we find depositions of secondary



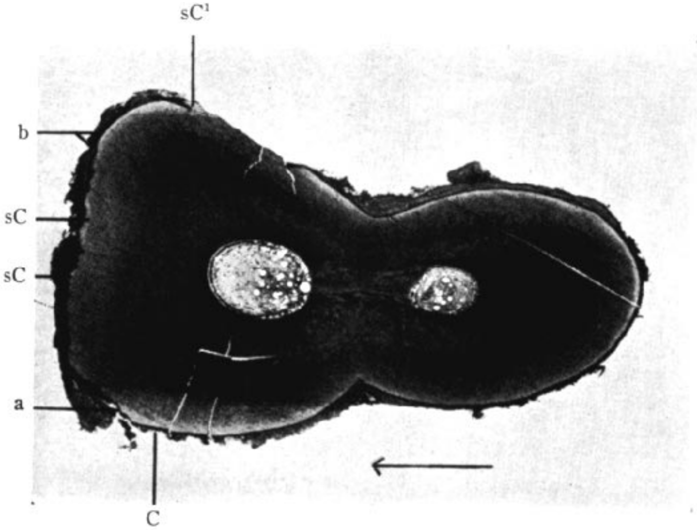
Specimen XI (Figs. 60 to 68) **Figure 62**

Magnification 12; for description see text.

cementum, (sC, Fig. 63). The secondary cementum seen in sC^1, Fig. 63, proves, as does that in Fig. 62, at almost the same place, that we are not dealing merely with an artificial defect. The intermediate pictures often show resorption again on the approximal surfaces which are not to be seen in this slide. Part a to b, Fig. 63, is shown in Fig. 64 in high magnification in two sections. Through lack of reliable marks (Anhaltspunkt), nothing can be mentioned about the depth of the resorption.

Still a little higher toward the alveolar-crest, Fig. 65, we find an extended cementum-resorption on the lingual side, reaching from a to b. This was brought about by the backward movement of the tooth (double arrow), the real length of which (measured along the curve of the dentin) was 2.3 mm. This resorption area is shown, magnified, in Fig. 66. Everywhere we find signs of repair, (sC, Fig. 66, secondary cementum), and no cementoclasts. At Ci, a little cementum-isle has resisted the resorption.

The pulp, Fig. 67, shows, in the right half, strong vacuolar degeneration of the odontoblast-layers, v. An approximately normal state of the odontoblast-layer has been preserved only in the left half, od. In the part situated more toward the crown, Fig. 68, the vacuolar degeneration is more strongly expressed in the left half of the odontoblast-layer of the left pulphorn, (v, Fig. 68). In the right pulphorn, the pulp has changed into one great oedema-

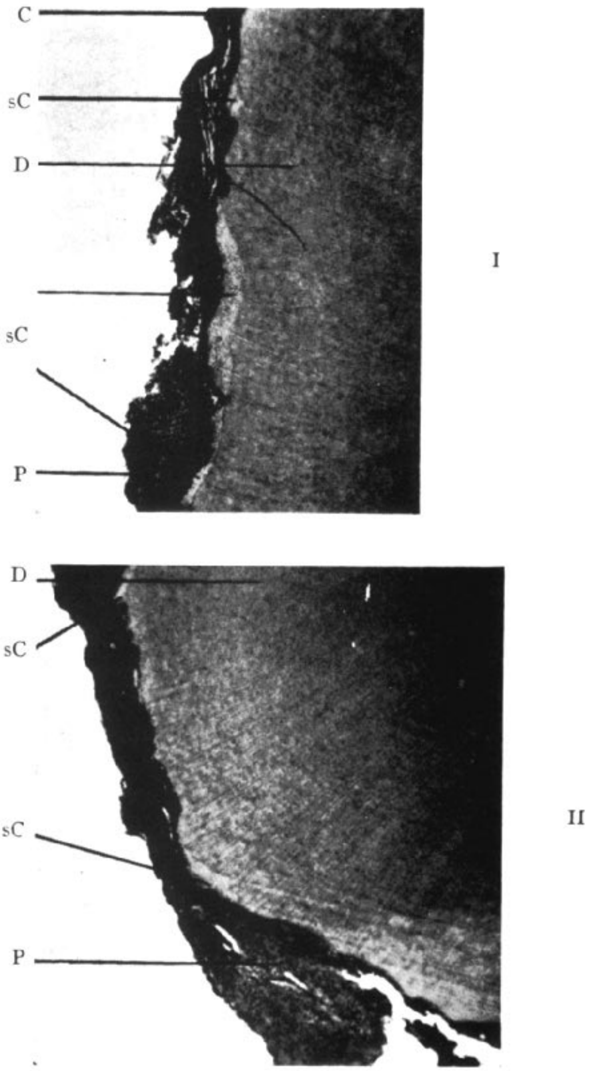


Specimen XI (Figs. 60 to 68) Figure 63
Magnification 12; a-b cementum-resorption; C, cementum, sC; secondary cementum. sC is described in the text.

gap, (Cy, Fig. 68). Remains of the detached bordering membrane are to be seen at Cw.

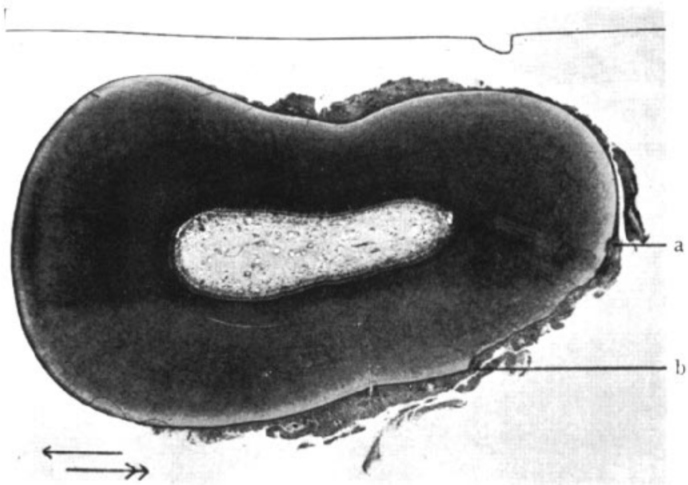
The bucco-lingual diameter of that oedema-gap, along the line a, is 1.2 mm. The mesiodistal, along the line b, measures 0.6 mm. Verification of the length of the oedema-gap from the crown towards the root (to be found by multiplication of the thickness of the sections with the number of the slides in which the oedema-gap, in succeeding sides, is uninterruptedly visible), is not possible in this specimen because of the incompleteness of the series. Also for this same reason no reproduction model was made.

Specimen XII. The first upper left premolar of the same case, Specimen XI, Fig. 60, was cut in a bucco-lingual direction. The buccal root has been fractured at the extraction. The specimen has therefore suffered essential damage but some single details are of interest which justifies their publication.

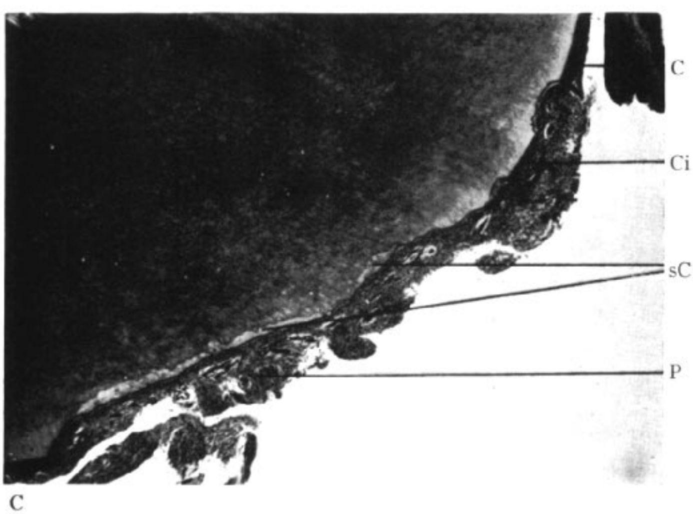


Specimen XI (Figs. 60 to 68) Figure 64
Higher magnification (40) of the upper (I) and lower (II) half of the resorption, shown in Fig. 63; C, cementum; sC, secondary cementum; D, dentin; P, detritus of periodontal tissue

In Fig. 69 we see an outline-picture which distinctly shows the deep resorption, a, on the buccal-side through the primary movement, (simple arrow) as well as the resorption, b, on the lingual side, produced by the back-

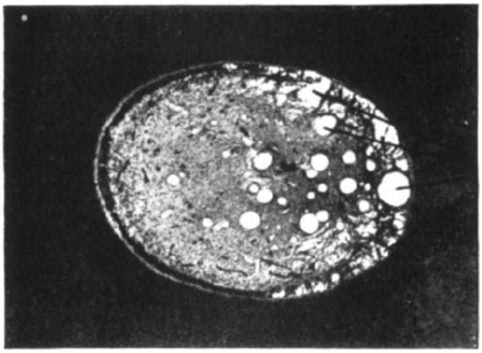


Specimen XI (Figs. 60 to 68) Figure 65
Magnification 12; primary direction of movement is indicated by the single arrow. By the backward movement of the crown (double arrow), the cementum-resorption (from a to b), near the alveolar crest, was formed.



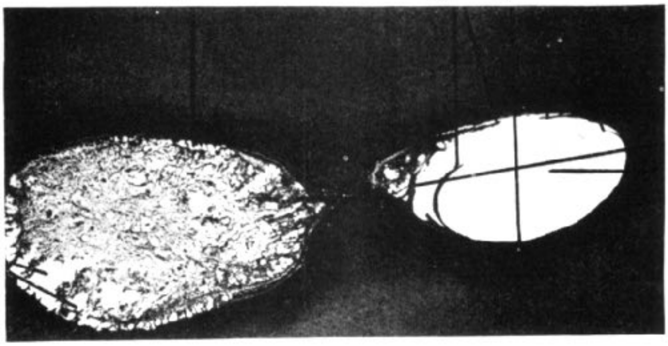
Specimen XI (Figs. 60 to 68) Figure 66
Points a and b of Fig. 65; magnification 40; C, cementum; sC, secondary cementum; Ci, cementum isle; P, detritus of periodontal tissue.

ward movement. Sometimes both resorptions are of equal extension and depth. We find, analogous to these, resorptions within the intra-radicular septum brought about by the jiggling movement. By the constant change of



Specimen XI (Figs. 60 to 68) Figure 67

Pulp of Fig. 63 (left half) in higher magnification (40). Far advanced vacuolar degeneration (v); normal odontoblast layer on the left (od).



Specimen XI (Figs. 60 to 68) Figure 68

Pulp more crownward than in Fig. 67; magnification 30; in the left pulphorn, contrary to Fig. 67, the left and upper half of the odontoblast layer shows vacuolar degeneration (v), while in the right pulphorn the whole pulp has changed into one large oedema-gap (Cy); Cw, remnants of the detached bordering membrane.

the pressure-sides, through the continual change of the direction of movement, the two opposite lying resorptions, c and d, Fig. 69, have been produced in the lower part of the intra-radicular septum. In calling back to memory the sketch seen in Fig. 17, the localization of these resorptions, c and d, becomes unquestionably clear. But we also find a still further extremely deep-reaching resorption, e, which runs parallel between the pulp and tooth-wall. Owing to the existing depth, any deviation from this direction was bound to lead to a perforation into the pulp. This part is shown in Fig. 70 in high magnification.

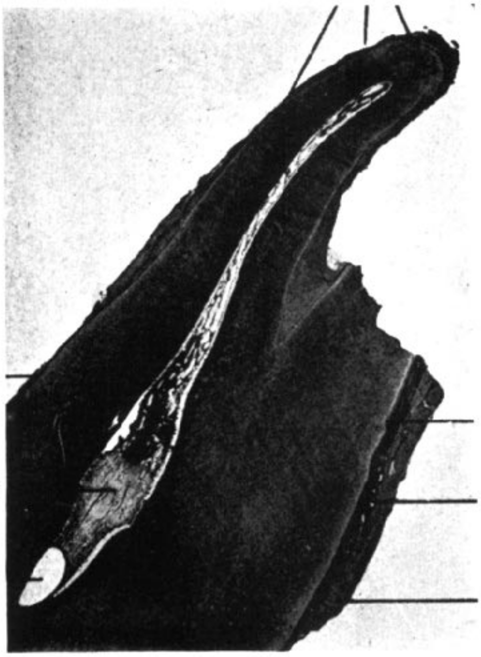
Specimen XII (Figs. 69 to 73) Figure 69
Magnification 12; primary direction of movement is indicated by the single arrow; backward movement by the double arrow; a and d, resorptions through the primary movement; b and c, through the backward movement; e, a very deep reaching canalizing resorption.

In the further course of the series, Fig. 71, the great resorption, a, of Fig. 69, has disappeared only to reappear later. We find only a small resorption, a, and the corresponding resorptions in the apex-sphere, due to the primary tilting movement, (a^1, Fig. 71). The resorption on the lingual-side of Fig. 69, brought about by the backward-movement, continues though in a somewhat changed form, (b, Fig. 71). This part, b, is shown in Fig. 72 in higher magnification and just as in the premolar on the right side, the healing-processes are in the foreground, (secondary cementum, sC, Fig. 72). No cementoclasts are ascertainable. In Ci, we see a cementum-isle which has been left. The lingual resorption, (b, Fig. 71), can uninterruptedly be followed in 107 sections. Therefore it has (in the certainly wrong assumption for this specimen that no slide has been lost) at least a mesiodistal extension of (0.016 x 107)* 1.7 mm.

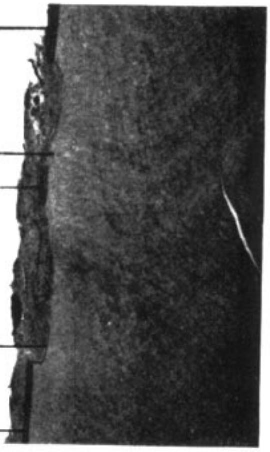
Specimen XII (Figs. 69 to 73) Figure 70
Points c, d and e of Fig. 69; magnification 40; description corresponding to Fig. 69.

As on the right premolar, Specimen XI, we also find on the left premolar, far advanced vacuolar degeneration of the pulp which, by confluence of the vacuols in a pulp-horn, as in Fig. 68, has finally led to the formation of a great oedema-gap, occupying the whole pulp-horn. In Fig. 73 we see the crown pulp of Fig. 71 in higher magnification. The odontoblast-layer on the left pulp-wall is thinned by insertion of smallest vacuols while numerous, almost confluent vacuols, are visible on the right side, v, which at Cy have

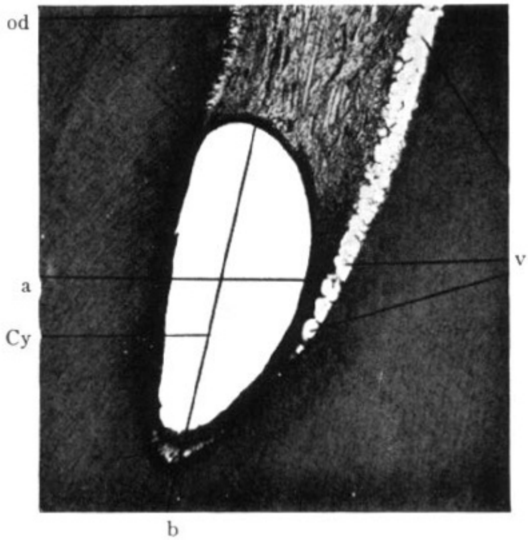
*The thickness of the slides multiplied by their number.



Specimen XII (Figs. 69 to 73) Figure 71
Magnification 8; primary direction of movement is indicated by the single arrow; backward movement by the double arrow; the buccal root is broken; a, resorption from the primary movement; a¹, correlating resorptions in the region of the apex; b, resorption from the backward movement; B, bone; Ps, periodontal space; P, pulp; Cy, oedema-gap.

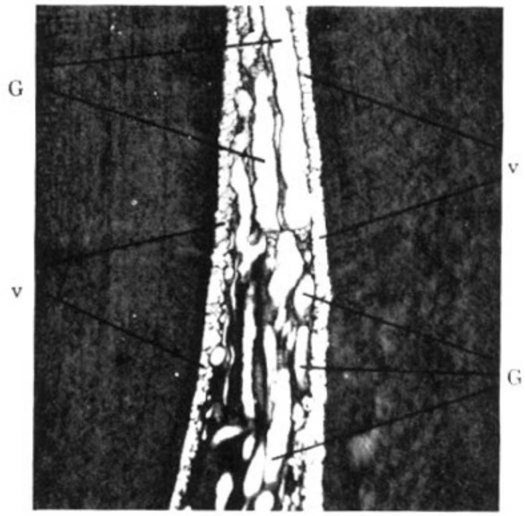


Specimen XII (Figs. 69 to 73) Figure 72
Point b of Fig. 71; magnification 42; C, cementum; sC, secondary cementum; Ci, isle of cementum.



Specimen XII (Figs. 69 to 73) Figure 73

Crown pulp of Fig. 71; magnification 40; od, odontoblast layer attenuated by the interposition of the smallest vacuoles; v, vacuoles mostly confluent with each other; Cy, great oedema-gap.



Specimen XII (Figs. 69 to 73) Figure 74

Root pulp of Fig. 71; magnification 40; G, vessels; v, vacuoles.

led to the formation of a single great oedema-gap. The dimensions of this are 0.50 mm. in the bucco-lingual direction along the line, a. The height along the line, b, measures 1.3 mm. The mesiodistal diameter was also calculated here by the multiplication of the thickness of the single slides, 0.016, with the number of the slides, 78, in which this oedema-gap was visible without interruption. The mesiodistal diameter is therefore 0.016 times 78 or 1.25 mm.

In Fig. 74 we see the root-pulp in which neither real pulp-tissue or a regular odontoblast-layer can be ascertained. The latter is substituted by dense rows of vacuols, v. The stroma of the pulp has been substituted with numerous, strongly widened vessels (G).

(*To be continued*)