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RALPH C. MATSON[2]

A careful analysis of statistics furnishes most convincing evidence of the value of artificial pneumothorax in the treatment of pulmonary tuberculosis. However, its success is almost in direct proportion to the number and character of adhesions present, and preventing satisfactory collapse of the lung. According to our experience pleuritic adhesions cause more failures in pneumothorax therapy than any other complication, 40 per cent of its failures being caused by such adhesions interfering with satisfactory compression.

Adhesions, unfortunately, are most often distributed over the more diseased parts of the lung, being almost invariably present over superficial cavities. Thus, the very part of the lung which is in greatest need of rest or collapse is least likely to receive it. It is a frequent observation that a single string or band, extending from a partially collapsed lung to the thoracic wall, holds open a cavity and renders the attempted pneumothorax a failure. (Figures 1 and 2.)

The value of satisfactory pneumothorax in which adhesions did not prevent the closure of cavities or adequate rest of the lung as compared with partial pneumothorax in which adhesions did impede the mechanical and physiological benefits of a pneumothorax is shown in table 1.

Early in our experience we were convinced of the advisability of converting a partial pneumothorax into a satisfactory one, and for years we resorted to stretching the offending adhesions by gently increasing the intrathoracic pressure, since we regarded the open operations or closed operations under X-ray control, for the purpose of cutting adhesions, as

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much too dangerous, and the result as not justifying the risk involved. At the same time, efforts to secure a satisfactory pneumothorax by stretching adhesions left much to be desired. The results on the whole were unsatisfactory, as is indicated in the results in our partial-collapse cases shown in table 1.

In 1913 Jacobaeus of Stockholm devised an ingenious method of dividing adhesions by means of a galvanocautery, introduced at one point through the chest-wall and operated under the guidance of a thoracoscope inserted through the chest-wall at another point.

The original Jacobaeus thoracoscope had a limited and reduced field of vision, making the operation difficult. In 1922 Unverricht developed a thoracoscope equipped with a Zeiss system of lenses that gave a superb view. Meanwhile, Jacobaeus has much improved his instrument, which now also gives a good view. And while the Unverricht thoracoscope has the advantage over the Jacobaeus instrument in that it gives a larger field of vision, it is at the same time more bulky, and radiates more heat from the larger light globe, which may introduce a factor in the formation of exudate. An attractive feature of the Jacobaeus instruments is that the cannulae for the thoracoscope and cautery are of the same size, so that either the thoracoscope or the cautery may be placed through a cannula after the trocar has been withdrawn. This permits an interchange of instruments during burning, and makes it possible to view the adhesions or burn them from two points without the necessity of more than two punctures, a procedure that may be advantageous in some cases of multiple adhesions. At the same time, the circumstance that only a straight-shaft cautery can be passed through the Jacobaeus cannula is a great inconvenience. We have found the curved-shaft cautery more applicable because it facilitates the approach to adhesions in any location.

A desirable feature perhaps of the Jacobaeus instruments is that sufficient space exists between the cautery shaft and the cannula to allow smoke to escape, and thus render it unnecessary to interrupt the operation in order to ventilate the pneumothorax cavity and rid it of smoke during the burning operation. However, a distinct advantage of the Unverricht outfit is the flexible cannula through which one may pass either a straight or curved-shaft cautery.

Since the perfection of technique of burning adhesions under thoracoscopic control, according to the method of Jacobaeus and Unverricht, we have employed this operative procedure during the last three years on all suitable cases.

The general impression is that operations for the division of adhesions are seldom really indicated. This is contrary to our experience. In a careful re-study of 91 cases now dead in our partial-collapse series, shown in table 1, we found that, from a roentgenological standpoint, 36 or 40 per cent were suitable cases for burning earlier in their pneumothorax career, and that, had they been operated upon, instead of resorting to the stretching of adhesions and prolonged partial-pneumothorax treatment, probably 50 per cent would be alive and well to-day.

Of 268 cases subjected to artificial pneumothorax during the past three years, adhesions prevented satisfactory pneumothorax in 69, or 25.9 per cent. Of this latter number, 31, or 45 per cent, proved suitable for the Jacobaeus-Unverricht operation. The other operated cases reported

TABLE 1

Comparative value of artificial pneumothorax in cases in which adhesions did not prevent adequate functional rest and closure of cavities, and those in which adhesions did prevent sufficient collapse of the lung to close cavities or give the necessary functional rest
Observations on 850 cases: January 1, 1911, to August 1, 1925

CHARACTER OF PNEUMOTHORAX	CLINICALLY WELL	ARRESTED	DEAD
	per cent	*per cent*	*per cent*
Satisfactory collapse, adhesions not preventing closure of cavities or adequate rest of the lung	48	20	21
Partial collapse, adhesions preventing satisfactory closure of cavities or adequate rest of the lung	13	13	50

in this paper were referred cases and those that began their pneumothorax treatment before we resorted to this operation.

TECHNIQUE

The preoperative preparation consists in a determination of the bleeding and coagulation time of the blood and blood-grouping. A pneumothorax refill should be done a day or two before the operation, so as to provide as large as possible a pneumothorax in which to work. The chest is prepared the night before operation by shaving, and an alcohol pack is applied as for a thoracoplasty. One-half hour before operation the patient receives, hypodermatically, morphine sulphate, gr. $\frac{1}{6}$ to $\frac{1}{4}$, in 2 cc. of 50 per cent magnesium-sulphate solution.

The surgical technique calls for careful observance of scrupulous asep-

sis such as obtains in other major thoracic operations. The instruments (figure 3), including cables, should be sterilized by formaldehyde. We have found the Wappler formaldehyde sterilizer, using formalin tablets decomposed by heat, to be the most satisfactory. The instruments should be sterilized the day before and wiped free of formaldehyde before the operation. There should always be 1000 cc. of sterile normal salt solution and 250 cc. each of 2.5 per cent and 5 per cent oil of gomenol at hand to be used, as commented upon later.

The patient is placed on the table with the pneumothorax side up and the good side resting upon a hard pillow. After painting with iodine or picric acid and alcohol, the patient is draped as shown in figures 4 and 5 for a posterior approach, which will be the point of entrance of the thoracoscope in the majority of cases, as most adhesions will be found in the posterior upper quadrant of the pneumothorax.

The operation is preferably done in an absolutely dark room, which not only improves the operator's vision, but the light from the thoracoscope will then illuminate the pneumothorax field like a Japanese lantern. The shadows of the ribs, as well as attachments of large adhesion-folds, are clearly visible, unless the pleura is too thick. Thus, valuable information may be gathered regarding the site of the attachment of adhesions to the chest-wall, and this will then serve as a useful guide for entrance of the cautery.

All instruments should be thoroughly tested beforehand, and the electrical currents adjusted to give the proper amount of light in the thoracoscope and heat in the cautery. A Wappler wall-transformer has proved most satisfactory for regulating the light- and heat-currents.

The point of entrance of the thoracoscope will depend entirely upon study of the stereoscopic films. One should introduce the thoracoscope at a point where the best view of all surfaces of the adhesions will be obtained. Because of the thickness of the muscles in the interscapular region, it is advisable to avoid this area. One seldom need go higher posteriorly than the 6th or 7th intercostal space. If a higher approach is necessary for study of apical adhesions, one may preferably introduce the thoracoscope anteriorly in the 1st or 2nd intercostal space.

The site of puncture, previously determined by a study of the stereoscopic films, is infiltrated with 1 per cent novocaine-suprarenin solution. It is unnecessary to anaesthetize the intercostal spaces above and below the site of puncture, but care should be taken to infiltrate the endothoracic fascia and secure a good anaesthesia of the parietal pleura. The

presence of a pneumothorax beneath the site of puncture should be verified by passing the needle through the chest-wall and aspirating air with the syringe.

A one-centimetre incision is made with an iridectomy knife through the skin. This incision should be made in the direction of the external intercostal fibres, so that the puncture site may be closed with a single catgut suture, including the thoracic fascia and some of the fibres of the external intercostals, if possible. The trocar and ball-valve cannula for the thoracoscope is pushed gently through the chest-wall. (Figure 6.) Every precaution must be exercised to avoid plunging the trocar into adherent lung, adhesions or other structures. After withdrawing the trocar, the thoracoscope is introduced with the lens up so as not to smear it with the usual drop or two of blood which runs down the cannula from the chest-wall puncture. It is furthermore advisable to introduce the thoracoscope in as nearly a horizontal direction as possible.

Keeping in mind the stereoscopic image, one should study adhesions which are of technical importance with great care. (Figure 7). One must have complete orientation regarding their position and direction with relation to the chest-wall and collapsed lung, as well as their dimensions, configuration, and distance from the lens and other anatomical structures. It is particularly necessary to know how close the point of cauterization is to large blood-vessels and important nerve-trunks. The presence of lung tissue, blood-vessels and tuberculous deposits in the adhesions to be burned should be determined, following which a study should be made of the inner chest-wall and that site selected for entrance of the cautery which will give an unobstructed view and permit placing the cautery in the most advantageous position across the adhesion at a right angle for purposes of burning. (Figure 8). If multiple adhesions are present, particular care must be exercised that the cautery is introduced at a point most favorable for attacking all adhesions. One must especially avoid entering the cautery at a point where adhesions prevent its being seen, as, for instance, on the blind side of adhesions. (Figure 9).

The point of entrance of the cautery will depend entirely upon the thoracoscopic findings, but, as a rule, the cautery can be most advantageously introduced in the axillary line,—the more anteriorly, the better, as the intercostal spaces are wider toward the front and permit a greater degree of manipulation.

After selecting the site of entrance for the cautery, the area is infiltrated with novocaine-suprarenin. If the operator is properly orientated, he

may observe through the thoracoscope the needle of the infiltrating syringe emerging through the pleura. The needle should then be withdrawn until it disappears from the pleura into the endothoracic fascia, which should be thoroughly infiltrated with the anaesthetic. This infiltration will be seen through the thoracoscope as a blanched area elevated like a wheal on the inner chest-wall. Good anaesthesia of the parietal pleura and chest-wall is desirable, as heat from the cautery shaft is likely to be painful. The trocar and cannula for the cautery are then introduced. A cautery is selected, either curved or straight, which will give the best approach to the adhesion, and before introduction it is tested again and brought to a cherry-red glow. After permitting the cautery to cool, the trocar is withdrawn, thus allowing the pneumothorax to equalize itself with atmospheric air. The cautery is then introduced through the cannula and observed through the thoracoscope. (Figure 10). Keeping in mind the location of the adhesion to be burned, the tip of the cautery is kept in the field of vision of the thoracoscope, while the eye-piece of the latter is rotated so as to bring the adhesion into view.

The cautery is then placed upon the adhesion which is now tested for sensation. This manoeuvre gives valuable information as to whether the pleura covering the adhesion is reflected from the lung or the chest-wall, as only the latter has sensory-nerve fibres. If the adhesion is broad, it may be lifted with the tip or shaft of the cautery and examined for blood-vessels underneath. In proceeding to cauterize the adhesion, one should bear in mind that the closer the burning is to the chest-wall the greater will be the pain and the danger of bleeding, inasmuch as sensation comes from the intercostal nerves and the blood-supply is derived collaterally from the intercostal vessels. On the other hand, burning near the lung, while painless, is dangerous, because one may burn into a small cavity projecting within the adhesion, or into the lung, and thus liberate infection which is almost certain to result in empyema. Generally speaking, the cauterization should be made where the adhesion is the thinnest.

If the patient's stereoscopic films before operation show a short adhesion, a careful examination should be made to determine whether the adhesion contains an elongated cavity. Cases of this character should be burned as close as possible to the chest-wall, which is likely to be painful and sometimes dangerous because of the possibility of bleeding. However, pain can be controlled by infiltrating the chest-wall attachment with novocaine-suprarenin under thoracoscopic guidance.

The cauterization should proceed slowly and cautiously. If blood-vessels are seen, they should be thrombosed with the flat surface of the cautery before cutting. (Figure 11.) Should bleeding occur, it is stopped at once by the application of the heated cautery or by radiating heat from it. While the tip of the cautery may be in a safe situation and in full view, the operator should see to it that the cautery-shaft, which is not in view, is not resting upon the lung or other important structures which might be damaged by its heat. He should also avoid cauterization in close proximity to large blood-vessels or nerve-trunks, as radiating heat may result in phlebitis or vascular thrombosis, or painful neuritis or shock, if one works too near the sympathetic trunk.

The beginner will do well to confine himself to string- and band-adhesions and avoid diffuse folds. It must be a fixed rule never to burn any tissue until all surfaces have been seen, and no tissue should be cauterized unless the operator is perfectly familiar with its structure. In this way accidents will be avoided. Prolonged cauterization should never be practised, and the cautery-shaft should be allowed to cool at frequent intervals. In addition to the dangers referred to above, I am certain that radiating heat from the cautery is an important factor in the formation of exudate and occurrence of postoperative pain.

The cauterization of large adhesions often gives rise to much smoke inside the pneumothorax space which obscures the visual field. If such is the case, the thoracoscope should be removed and the cannula substituted. The patient is instructed to take a few deep breaths, whereupon air will be sucked in during inspiration and smoke forced out on expiration. If the lens becomes smeared with exudate or blood, the thoracoscope must be removed and wiped clean.

After the adhesion is completely cut through, a careful search should be made, first of the chest-wall stump for bleeding vessels, and then of the lung stump. Any oozing should be stopped by application of the cautery. Bleeding is much less likely to occur from the lung-stump than from the chest-wall stump, as it will be observed that the lung-stump contracts after cauterization to less than half its size before cauterization. (Figure 18–*4*.)

Cauterization with the galvanocautery has many shortcomings from the standpoint of heat and character of cutting. It has been shown that tissue is destroyed for a very short distance around the cautery; blood-vessels are destroyed, and, unless a very dull red heat is used, bleeding may occur. This makes the operation at times tedious. I have over-

come these objectionable features recently by using the electrothermic method, utilizing for this purpose the Wappler-Wyeth endotherm with special electrodes which I have designed. (Figure 12.)

Briefly, the cutting effected by the endotherm is not a true cutting but a molecular disintegration of the tissues produced by a high-frequency undamped current, an arc being formed at the point of contact between the tip of the electrode and the tissue. By this method, blood- and lymph-vessels are sealed; no bleeding occurs, and the danger of liberating tuberculous infection from the cut adhesion is infinitely less. There is no radiating heat, the electrode-shaft remaining cool. There is much less pain when cutting near the chest-wall, and the operation is more quickly executed. Although my experience with this new method is limited, I am sure that the electrothermic method overcomes all of the objections of the galvanocautery and will replace the latter method.

After the operation is finished, the cautery and its cannula are removed, and then the thoracoscope, after which the pneumothorax cavity is freed of smoke by inserting a cannula for this purpose. This leaves the pneumothorax at atmospheric pressure, which is desirable, as positive pressure favors emphysema and the tearing of incompletely cauterized adhesions, while negative pressure favors bleeding. After the pneumothorax space has been freed of smoke, the thoracoscope cannula is removed and a deep stitch is made at the site of puncture. The patient should be emphatically warned at this time against coughing. A small roll of one-inch bandage for compression is made over the site of puncture. This is covered with sterile gauze, and the chest is tightly strapped with several strips of three-inch adhesive plaster extending well to the front and back.

The postoperative care consists of absolute bed-rest with the pneumothorax side up. Cough should be controlled during the first forty-eight hours with opiates, if necessary. Bed-rest should be maintained for seven days. Straining at stool and physical effort, including excessive laughter, should be warned against.

The first reinflation after operation is made with carbon dioxide because its use lessens the danger of gas embolism. The time and quantity of gas reinflation will vary with each individual case. It is sufficient if carbon dioxide is introduced within three or four days. If large cavities are present, collapse of the lung should be brought about gradually with small quantities of gas because of the danger of kinking the drainage bronchus, and the consequent retention of sputum in the cavity. (Figure 13.)

Reinflation should be carefully controlled by the X-ray and a film should be made, preferably after every gas injection for the first few times. If the drainage of a cavity is interfered with, it may be necessary to aspirate gas and expand the lung slightly so as to establish drainage, following which frequent fillings with small quantities of air should be carried out until a satisfactory collapse is established and the patient rendered sputum-free.

At times it is surprising how quickly sputum disappears. If sputum is still raised and contralateral-lung sources can be excluded, the collapse should proceed to compression, using positive pressures if necessary. Should anteroposterior films reveal no residual cavity, lateral films should be made, and the pneumothorax carried on energetically until no sputum is raised. (Figures 14 and 15.)

The postoperative course is, as a rule, mild. Elevation of temperature of to 100° or 101°F. usually follows and sometimes lasts a week. In case of string- or band-adhesions up to 2 cm., at times, no reaction takes place, and the procedure is scarcely more objectionable than a pneumothorax puncture.

INDICATIONS

In considering the indications for cauterization, the first requisite is that the case be one in which, after a reasonable length of time, it can be demonstrated that adhesions are preventing satisfactory collapse of the lung, and recovery is doubtful with a continuation of the partial pneumothorax. There should also be reasonable assurance that the patient will recover, provided a satisfactory collapse is established. In other words, there must be an absence of any serious complication such as extensive disease in the contralateral lung or the intestines, which would probably prevent the patient's recovery even if a satisfactory pneumothorax were established.

Further indications are, first, unsatisfactory pneumothorax on account of incomplete collapse of the lung because of strings, bands, and folds of adhesions; second, satisfactory pneumothorax in spite of adhesions, when high intrathoracic pressure is necessary to maintain the collapse, with consequent danger of lung rupture, and when pressure is furthermore causing uncomfortable symptoms, such as phrenic dyspepsia, coughing paroxysms, and so forth; third, satisfactory pneumothorax in which bands of adhesions have become organized, causing early expan-

sion of the collapsed lung in cases in which the pneumothorax has not been maintained sufficiently long.

With reference to the first group of cases, we feel that it is unjustifiable to keep up an unsatisfactory pneumothorax. The cauterization of adhesions should be considered, if, after a few months of trial, the twenty-four-hour quantity of sputum, after perhaps a preliminary fall, remains more or less stationary, and X-ray study shows that satisfactory collapse of the lung is prevented by adhesions of a reasonably suitable type for cauterization. We formerly used to resort to high intrathoracic pressure, hoping to stretch the offending adhesions. This practice was occasionally successful, but after long experience and study of our end-results we are convinced that this procedure is inadvisable. We believe it better to employ the cautery, if possible; otherwise, utilize other collapse measures, either in conjunction with the pneumothorax or by converting the pneumothorax into an oleothorax and carrying out such other compression procedures as partial or complete thoracoplasty after phrenicotomy, or abandoning the pneumothorax and doing a complete thoracoplasty. Figures 16 to 29 illustrate cases of this type.

The second group of cases comprises those in which the intrathoracic pressure necessary to maintain collapse of the lung causes downward pressure upon the liver and stomach or uncomfortable mediastinal displacement. These patients frequently complain of nausea and anorexia, and either lose weight or fail to gain. In other cases traction of adhesions upon the lung provokes annoying paroxysms of coughing. After cauterization of such adhesions, less frequent refills of gas will be required and the necessity of high intrapleural tension with its dangers will be done away with; it will also relieve pressure upon the liver, stomach and mediastinum. An example of this type of case is shown in figures 30, 31 and 32.

The third group of cases is also commonly met with by those engaged in pneumothorax work. Not infrequently bands of adhesions become organized and contract, and pull out a lung which has had a good collapse. This is often followed by expansion of the lung with recurrence or increase of expectoration, and sometimes haemoptysis. Our policy in these cases is to cauterize these strings or bands and establish a good pulmonary collapse, and then convert the pneumothorax into an oleothorax which prevents further expansion of the lungs. Figures 33, 34 and 35 illustrate a case of this type.

If cauterization is contemplated, it should be done early, before adhesions become organized and collateral circulation is established, and before bronchogenic extension of disease takes place to the same or the contralateral lung.

CONTRAINDICATIONS

Tuberculous disease in the contralateral lung is no contraindication *per se* for the cutting or cauterization of adhesions that prevent satisfactory collapse of a lung. Even a pneumothorax on the contralateral side is no contraindication, provided the indications for bilateral pneumothorax exist. Obviously, the contraindications are the same as those for a satisfactory pneumothorax. The presence of benign exudate is no contraindication, as will be noted later. Cauterization should not be done during an acute formation of exudate. Acute pyothorax contraindicates cauterization, but chronic afebrile pyothorax is not a contraindication *per se*. If, however, there is profuse purulent exudate, it will be found that the adhesions are so covered with fibrin and purulent debris that the nature of tissue to be burned is difficult to determine.

Serous exudate should be aspirated before cauterization is attempted, and in case of purulent exudate one should try to clear up the infection by oleothorax treatment and then aspirate the oil of gomenol before operation. If only a small quantity of purulent exudate is present, the pneumothorax should be thoroughly washed out with normal salt solution before cauterization is attempted. We have cauterized two chronic afebrile cases with purulent exudate, and without unfavorable result. However, we have limited our operations to string- and small band-adhesions. The strictest care must be taken in these cases to prevent infection of the puncture wounds through the chest-wall which may terminate in thoracic fistula. We routinely introduce 150 to 250 cc. of 2.5 to 5 per cent oil of gomenol in all cases in which purulent exudate was present before operation, or when we encounter tuberculous changes in adhesions during their cutting, or when caseous tubercles are seen on the visceral or parietal pleura. We are convinced that this precaution lessens the danger of infection.

SELECTION OF CASES

The selection of cases for cauterization should be made only after a careful study of, preferably, stereoscopic X-ray films taken before the pneumothorax and during its entire course. Stereoscopic-film study is obligatory before operation, in order that one may be perfectly informed

as to the position of cavities in the collapsed lung and their probable relation to adhesions, as well as the location of adhesions and their attachments to the lung and chest-wall.

A careful record of the influence of the pneumothorax on the twenty-four-hour quantity of sputum, as measured at weekly or monthly intervals, should be available. If the original film shows a superficial cavity, and serial films during the evolution of the pneumothorax show short adhesions holding the lung close to the chest-wall, it may be suspected that the adhesion contains a prolongation of the cavity or lung tissue, and cauterization would be dangerous. In the case of large cavities, the floor of the cavity is not infrequently mistaken on X-ray films for a band-adhesion, the cauterization of which would certainly be followed by bad results. (Figure 36.) Here a study of the quantity of sputum, and of the original films and stereoscopic films of the pneumothorax will serve as a useful guide. (Figures 37 and 38.) In case of doubt, 20 to 40 cc. of lipiodol may be injected into the pneumothorax space, and the patient examined under the fluoroscope in various positions that favor gravitation of the lipiodol to the upper part of the pneumothorax cavity. In case one has to deal with the wall of a cavity, the position of the lipiodol shadow and the inability of the lipiodol to pass behind or in front of the barrier will clearly indicate the nature of what was thought to be an adhesion. An example of this type of case is shown in figure 39. This patient was referred for cauterization of what was thought to be a band-adhesion extending from the collapsed lung to the chest-wall. (Figure 39–*2*). Study of the patient's sputum showed its reduction in quantity to be inconsistent with the apparent collapse; for, in spite of prolonged pneumothorax and a fair collapse shown on the single film, the quantity of sputum remained nearly the same, and the contralateral lung could be excluded as a source of sputum. While the film suggested a band between the partially collapsed lung and lateral chest-wall, clinical study was convincing that the cavity had been uninfluenced by the pneumothorax, and that what was formerly interpreted as a band-adhesion must be the floor of the cavity.

Lipiodol was injected into the pneumothorax space, and its movement noted under the fluoroscope as the patient was tilted, head down, on the table. This examination confirmed the opinion that what was thought to be a band-adhesion was the floor of the cavity, as it was impossible for the lipiodol to flow in front of or behind the obstacle. (Figure 40.) Thoracoscopic examination confirmed this opinion.

A careful study of stereoscopic films should be made before cauterization, but not too much dependence placed upon it, for at times one is perfectly amazed at the number of adhesions, which are not shown on stereoscopic films, but are to be found on thoracoscopic examination. In nearly every instance, one encounters adhesions not visualized by the most careful roentgenological technique.

Frequently, adhesions not shown on X-ray films are technical factors preventing collapse of the lung. I refer to string-adhesions as tough as catgut and scarcely any larger, extending from the partially collapsed lung to the chest-wall, and sometimes giving the partially collapsed lung a tented contour. In one of our cases, in which there was supposedly only a small band-adhesion present, we encountered a half-dozen slender strings of the type referred to above,—too fine to be shown on the X-ray film, and collapse of the lung did not take place until they were cauterized.

Not infrequently what appears to be a band-adhesion on stereoscopic films proves to be a diffuse fold-adhesion with a thick edge. (Figure 41.) Undoubtedly, the most valuable method of determining the possibility of cauterization is by thoracoscopic examination of the pneumothorax cavity, and in any doubtful case this procedure should be utilized, inasmuch as it is harmless.

RESULTS

During the past three years we have done 100 cauterization operations with the results shown in table 2. The results of the operation have to do with its immediate result and not the end-result of the pneumothorax, as that has no bearing on the operation, but is subject to the various factors which influence pneumothorax therapy. However, every case classified as *clinically and technically successful* means that complete cauterization of all adhesions followed by a satisfactory pneumothorax with prompt, sometimes immediate, disappearance of fever, cough and expectoration, was attained.

It will be noted that the greatest success was achieved in the string and band type of adhesions. The string-adhesions were from approximately 0.5 to 2 cm. in diameter and essentially round. The band-adhesions here dealt with were from 0.25 to 2 cm. thick, and 2 to 10 cm. wide.

Adhesions in the form of folds with broad bases are commonly met with between the apex of the lung and the dome of the thorax, as well as along

the posterior wall of the pneumothorax space, extending from the lung around the costovertebral gutter to the lateral aspects of the chest-wall. Adhesions of this type frequently look like bands on stereoscopic films. Our technical and clinical successes have been much fewer in cauterizing this type of adhesion. One can cautiously cut the free edge toward its base (figure 42, *1–2*) and, as shown in our results, sometimes secure a technically and clinically successful result. Our technically and clinically unsuccessful cases were entirely of this type.

TABLE 2

Intrapleural pneumolysis: Jacobaeus-Unverricht method: 100 cases

RESULTS OF OPERATION	NUMBER OF CASES	FOLDS	STRINGS AND BANDS	TOTAL PERCENTAGE OF CASES
Technically and clinically successful (satisfactory pneumothorax immediately, with disappearance of cough and expectoration)	63	6	57	63
Technically unsuccessful, clinically successful: incomplete cauterization	11	11		11
Total: Clinically successful	74	17	57	74
Technically successful, clinically unsuccessful: bilateral pneumothorax	1		1	1
Technically and clinically unsuccessful	25	25		25
Examined with thoracoscope and found unsuitable for operation (referred cases)	13	13		
Dead: Due to independent evolution of disease, as in other lung, intestines, etc., not related to operation	6			

In our series of 100 cases, there were 14 single string- or band-adhesions. In 44 cases there were multiple strings and bands, and in 42 cases diffuse folds. The diffuse-fold type of cases should not be attempted until one has had considerable experience with the method.

In 92 of our cases, a single cauterization operation was done, and 68 were successful and 24 unsuccessful. These latter were all cases with the diffuse-fold type of adhesions. In 4 cases two cauterizations were done, three of which were successful and one unsuccessful because of the presence of diffuse folds. In two cases, three cauterizations were performed with a successful end-result in each. Two cases were operated upon four times each. A satisfactory collapse was obtained in one; the other experienced improvement in the collapse but diffuse folds of adhesions prevented a satisfactory end-result.

In the case of single or multiple string-adhesions, one cauterization will usually suffice, but with multiple band-adhesions and folds it is often necessary to do repeated cauterizations. The following is a very interesting case of this kind:

Case 6093: (Figure 43): Female; age 24 years; sick one year. Physical and roentgenological examination revealed fibrocaseous tuberculosis with cavity, involving two-thirds of the right lung and with bronchogenic disseminations in the contralateral lung.

The average 24-hour quantity of sputum was 40 cc. Tubercle bacilli positive. Temperature range 100° to 101°F. in the afternoon. Weight 110 lbs.

A very gradual collapse of the right lung was instituted in spite of the disease on the contralateral side. At the end of a month the patient's general condition was improved. She had gained 3 lbs. in weight; her temperature ranged under 100°F.; but her sputum, after a preliminary fall the first two weeks to 25 cc. in 24 hours, remained stationary the following month in spite of larger gas refills and increasing intrapleural pressure. The contralateral lung showed no progressive changes.

Stereoscopic films of the pneumothorax at the end of six weeks (figure 44) revealed at least two cavities (*5* and *6*) held open by multiple string- and, probably, band-adhesions (*1*, *2*, *3* and *4*) extending from the partially collapsed lung to the dome of the pneumothorax space, particularly posteriorly, but some also anteriorly.

In order to secure a better collapse of the lung, cauterization was decided upon. Thoracoscopic examination, through a posterior approach, disclosed numerous strings and bands not shown upon the stereoscopic films. One large band (Figure 44–*1*), extending from the apex to the dome of the pneumothorax space, was cut, as were several string-adhesions (figure 44–*4*), all of which seemed of technical importance.

Other strings and bands were seen anteriorly, and apparently a fold extending from the lung across the costovertebral gutter to the posterolateral aspects of the chest-wall. The anterior string-adhesions did not seem to be of sufficient importance to prolong the operation, and the fold posteriorly seemed insignificant. However, in spite of the cauterization of several adhesions of importance, the 24-hour quantity of sputum remained essentially the same, although stereoscopic films (figure 45) showed the apical band had been cut and one cavity (*5*) was much smaller. Other small string-adhesions were also shown to have been cut.

A second cauterization anteriorly was decided upon, as it seemed probable that the strings of adhesions anteriorly were of greater significance than at first estimated. Accordingly, the thoracoscope was introduced anteriorly in

the second intercostal space in the midclavicular line. A good view of the pneumothorax was obtained, and again two string-adhesions, which alone seemed of technical importance, were cut. There was also seen, at this time, the fold of pleura extending upward from the collapsed lung across the costovertebral gutter, but it was not even at this time considered of technical importance. Besides, it had all the appearance of an unapproachable fold. Moreover, it was felt that the two remaining string-adhesions, shown in figure 45 at *2* and *3*, had been severed. However, much to our surprise, stereoscopic films after the second cauterization revealed no essential changes in the pulmonary collapse. (Figure 46.) Apparently what had been considered an insignificant fold, when viewed at a distance during the two previous operations, was a structure of greatest technical importance.

While, upon thoracoscopic examination, the offending structure appeared to be a fold, it had the appearance of two bands on stereoscopic films. Accordingly, to determine whether it was a fold of pleura which probably could not be safely cut, or a band-adhesion which could be cut without danger, 20 cc. of lipiodol was injected into the pneumothorax cavity. The patient was placed recumbent upon the fluoroscopic table, and the head of the table was slowly lowered so that the movement of the lipiodol could be noted. It was seen to flow slowly toward the adhesion, and then penetrate it near the middle, and then appear above it. (Figure 47.) By rolling the patient, the lipiodol (figure 47–*1* and *3*) was made to surround the attachment of the adhesion to the chest-wall (figure 47–*2*), which appeared as an irregular area of lessened density amid the opaque shadow of the lipiodol.

Upon elevating the head of the table the lipiodol above the adhesion was seen to flow back through the opening into the pneumothorax cavity below. We were thus convinced we had to deal with a fold-adhesion, that had a small opening posteriorly and extended from the lung over the uncollapsed cavity across the costovertebral gutter, and was attached to the chest-wall between the 6th and 8th ribs in the scapular line.

Accordingly, a third attempt was made to secure collapse of the lung. To accomplish this the thoracoscope was introduced through the 7th intercostal space in the scapular line. Upon thoracoscopic examination the adhesion (figure 48) had every appearance of a fold of parietal pleura without any opening beneath. However, exploration with the author's blunt electrode brought to light the opening (figure 49) through which the lipiodol had been seen passing. As numerous blood-vessels were present, electrocoagulation with the blunt electrode and bipolar current was first done. The adhesion was then cut (figure 50) with the endothermic electrode without any bleeding whatever, and a satisfactory collapse of the cavity followed immediately. (Figure 51). The patient's sputum was reduced to 3 cc. within one week after the cauterization.

It is always advisable to avoid prolonged cauterization, although one to two hours may be borne very well by the patient if one proceeds slowly, and interrupts the operation frequently in order to let the cautery cool if the galvanocautery is used. During these intermissions the light of the thoracoscope should be shut off.

Prolonged cauterization is undesirable because of reactions caused by chemical changes which tissue proteins undergo at the site of cauterization, and also because of the effect of radiating heat from the cautery upon the pleura and other anatomical structures. This danger is strikingly brought out in

Case 6172: (figure 52): Female; sick one and one-half years. The physical and roentgenological examinations revealed a fibrocaseous tuberculosis, with cavity, involving the upper half of the right lung, and perihilar infiltration on the contralateral side. The patient's sputum averaged 33 cc. in 24 hours and was positive for tubercle bacilli.

Pneumothorax treatment was instituted, but after 5 weeks, in spite of constantly increasing amounts of air on refills, the sputum was reduced to only 30 cc. in 24 hours and the intrapleural pressure became positive. While stereoscopic films revealed no evidence of adhesions (figure 53) the lung was not collapsed as much as one would expect, considering the amount of air injected. Consequently, in spite of the roentgenological findings, adhesions were suspected of interfering with the collapse of the lung.

Stereoscopic film study at this time (figure 54), after a large refill of gas, showed a string-adhesion extending from the upper lobe to the lateral chest-wall. Of greater importance, however, was an adhesion attached near the sternal end of the first rib, and passing downward, backward and inward to the partially collapsed apex of the right lung. Thoracoscopic examination confirmed our roentgenological impression regarding the location of the adhesion. The lower adhesion extended from near the interlobar fissure between the upper and lower lobes of the right lung to the posterior lateral chest-wall. (Figure 55.) The apical adhesion, however, was a fan-shaped band with its broad base attached to the chest-wall. The most suitable place for cutting the adhesion lay only 2.5 cm. distant from the superior vena cava. (Figure 56.) Along the upper border of the adhesion a faint blue line was observed, extending from the chest-wall to the lung. This had somewhat the appearance of a large vein or a slender linear area which at a distance might be confused with a vein. The author's blunt electrode renders a very useful purpose in differentiating such structures, as the blunt end of the electrode permits the exploration of adhesions without the danger of injury to tissue. Thin areas on adhesions are transparent, whereas veins are not. (Figure 57.) If the structure had proved

to be a vein, one was in a position to obliterate it by electrocoagulation before cutting.

The possibility of heat from a galvanocautery damaging the vena cava when in such close proximity seems worthy of consideration, and supports our contention that the endotherm will replace the galvanocautery because of the essential absence of heat and the possibility of using a cutting or coagulation current in the endothermic outfit. Figure 58 is a thoracoscopic view of the adhesion cut by the endothermic method, and figure 59 is a film taken immediately after the operation.

In the case of multiple adhesions, if extensive, it is always well to cauterize those which seem, on thoracoscopic study, and with the stereoscopic image in mind, to be of technical importance. A careful check can be made by the X-ray after refills, and subsequent operations may be undertaken at weekly or monthly intervals, as the case demands.

Clinical success is not dependent upon the cauterization of all adhesions. Even apical adhesions do not always require cauterization, if sufficient horizontal collapse can be obtained, except in the case of superficial apical cavities when collapse is prevented by apical adhesions alone, or in cases in which vertical collapse of the lung is also necessary.

In instances of multiple adhesions attached to the lateral aspects and dome of the pneumothorax space it is often advisable to cauterize the lateral adhesions first, thus permitting more traction upon the apical ones, as frequently these are sufficiently stretched to render a second cauterization at a later date a much less dangerous affair. But in many instances a second cauterization will be found unnecessary. (Figures 60, 61, 62 and 63.)

In most cases innocent adhesions may be seen extending from the lung to the costovertebral gutter posteriorly, and anteriorly to the region of the sternum. Because of their proximity to large vessels and nerve-trunks these should not be molested unless there is unquestionable evidence that their presence is preventing satisfactory pulmonary collapse.

Adhesions attached to the lateral chest-wall offer no difficulty. Those extending from the apex of the lung to the dome of the thorax, while not technically difficult to cauterize, should be approached with timidity if they are short, and require cauterization near large blood-vessels or in proximity to the brachial plexus.

Diaphragmatic adhesions also offer no particular difficulty, according to our experience, and their cauterization is painless. If, however, they are extensive they should be let alone and a phrenicotomy performed.

COMPLICATIONS

We have had no serious accident (table 3). In 42 cases serous exudate was present at the time of operation, but in no instances were the quantities of fluid large. In cases with fluid the reaction to operation was no different than in those without fluid, except that, on the whole, more fluid occurred after operation than in the fluid-free cases. However, the end-result was in no instance impaired, nor was the postoperative course more stormy than in those without fluid at the time of operation.

Of the 58 cases without fluid before cauterization, 48 developed fluid after operation. In 28 of the latter it was moderate and required no aspiration, while 20 cases were aspirated and treated as cases in which fluid occurred during the course of pneumothorax. Purulent exudate

TABLE 3

Complications before and after operation in 100 cases

Serous exudate	Before operation, 42	Developed after operation, 48
Purulent exudate (tuberculous)	Before operation, 2	Developed after operation, 16
Purulent exudate (nontuberculous)	Before operation, 0	Developed after operation, 0
Haemorrhage (moderate; easily controlled by cautery), 1		
Severe reactions (high fever, etc.), 7		
Shock or serious operative complications, 0		

was present before operation in two cases, but it was not aggravated by cauterization. Sixteen cases developed empyema; all of them were tuberculous. In one case developing purulent exudate large conglomerate subpleural tubercles were seen in the lower lobe of the lung on thoracoscopic examination. Three cauterizations of apical adhesions were done at invervals of two weeks to a month. Three months after the last cauterization, empyema developed, and was treated with injections of oil of gomenol. The patient coughed up the gomenol when in a sitting position only, at which time the site of spontaneous rupture of the caseating tubercles in the lower lobe was submerged in the gomenol. It is our opinion that the empyema was in no way caused by the cauterization, but was due to the independent evolution of preëxisting disease.

In three of the 16 cases developing empyema tube-drainage was re-

sorted to; in nine the empyema cleared up under oleothorax, and four cases are still under oleothorax treatment but are doing satisfactorily. Tuberculous empyema was predicted in 7 cases before we resorted to oleothorax because during the cauterization scattered caseous tubercles were encountered in the adhesions. All of these were ordinary fold types.

It is our routine to place 150 to 250 cc. of 2.5 to 5 per cent oil of gomenol in the pneumothorax cavity after cauterization in cases in which pleural tubercles are seen and empyema is anticipated. We believe that it has had a very beneficial influence in preventing disseminated infection. We have had no empyema due to pyogenic bacterial infection. Bleeding to the extent of a few drops was frequently encountered in band and fold types of adhesions, but it either stopped spontaneously or was controlled by the cautery. Moderate haemorrhage occurred in one case (2 litres), but it was easily controlled by cauterization after the bleeding point was found; in this case multiple band-adhesions were cauterized. No bleeding occurred in any case with string-adhesions. Severe febrile reactions occurred in 5 cases. In one instance the fever lasted three weeks, and in two others less than ten days. No shock or other serious complications were observed. Slight subcutaneous emphysema sometimes occurs, when it is usually the result of uncontrolled cough or light strapping after operation.

COMMENT

This paper deals almost exclusively with the cauterization of adhesions according to the method of Jacobaeus, utilizing Unverricht's thoracoscope. However, our limited experience with the endothermic method has been so gratifying that recently we have adopted it routinely.

The details of the technique of cutting adhesions by the endothermic method is, in general, essentially the same as those for galvanocauterization, except that the underlying electrical principles involved are entirely different and require a thorough knowledge of the current being used, as well as other important particulars which will be communicated fully in a later publication.

The technique of cauterization of adhesions by the Jacobaeus-Unverricht method is simple and free from danger. The operator should be thoroughly familiar with the appearance of the pleural cavity and as thoroughly trained in the manipulation of the instruments with either hand. This training may be secured by inducing pneumothoraces on

tuberculous cadavers. For practice, I suggest a model of the human lung covered with a bird cage. Strips of paper may be pasted between the lung and cage to imitate adhesions, and the cage then covered with heavy paper. The thoracoscope and cautery are introduced, and practice exercised in approaching and burning adhesions running in any direction. The operator should be perfectly familiar with the distance of structures viewed through the thoracoscope. It is well to remember that what appears to be 1 cm. wide, if 1 cm. distant from the lens of the Unverricht instrument, will appear 0.2 cm. wide if 5 cm. distant from the lens. The tip of the cautery will serve as a useful gauge. This method of calculation is very important in estimating the size of adhesions and vessels, as well as the proximity of important structures to the point of cauterization.

We are convinced of the value of the Jacobaeus-Unverricht operation, and regard it as a distinct contribution and asset to collapse therapy. While in many cases a satisfactory collapse of the lung can be established in spite of adhesions, we regard attempts to stretch adhesions by high intrathoracic pressure more dangerous and less successful than cauterization. The operation of cauterization is a minor affair to the patient, and, if successful, will convert a useless pneumothorax into a satisfactory one and save the patient from thoracoplasty. The operator requires experience in phthisiology and surgery, and use of the method should be confined to surgeons with a pneumothorax background and experience in tuberculosis or to phthisiologists who have had a surgical training.

PLATE 1

Fig. 1. Short band-adhesion extending from the dome of the thorax to the lung, preventing closure of a large apical cavity

Average quantity of sputum in 24 hours, 60 cc.; tubercle bacilli positive. Pneumothorax one and a half years. No essential reduction in sputum for past year

1: Adhesion

2: Cavity

3: Note marked mediastinal bulging. Continuation of such a pneumothorax is futile

Fig. 2. Same case as fig. 1, one week after cauterization of adhesion

Average quantity of sputum in 24 hours, 15 cc. A typical example of the immediate effect of cauterization of offending adhesions

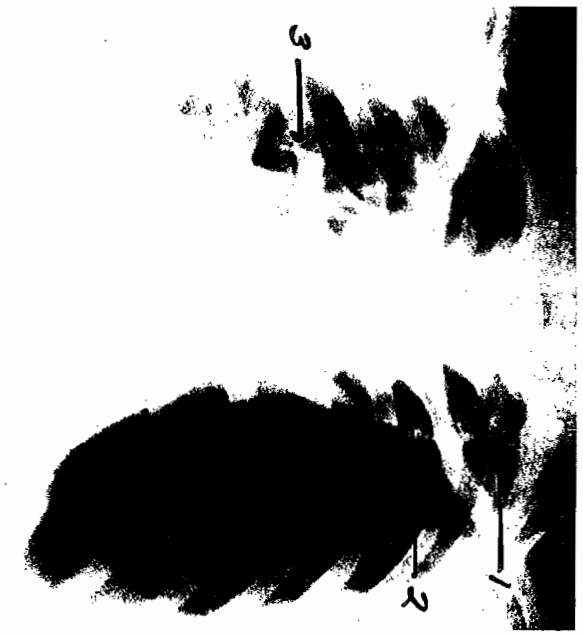


PLATE 1

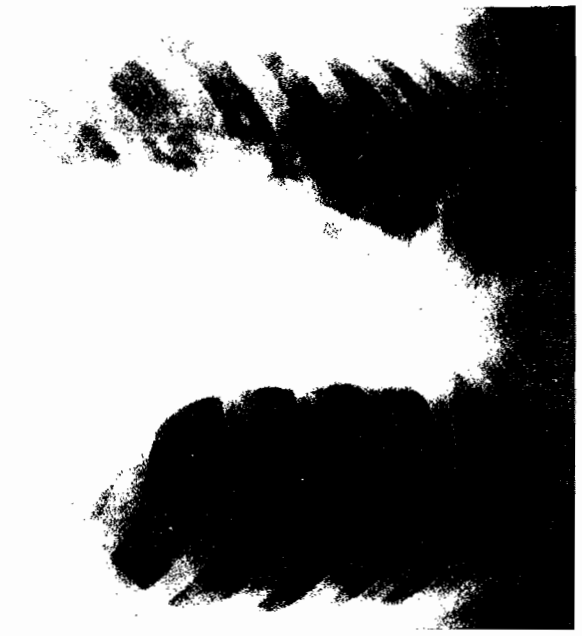


PLATE 2

Fig. 3. Jacobaeus and Unverricht instruments
1: Unverricht curved cautery
2: Jacobaeus straight cautery
3: Unverricht thoracoscope
4: Jacobaeus thoracoscope (note difference in size)
5: Trocar and cannula with ball-valve for Unverricht thoracoscope
6 and *7:* Jacobaeus trocars and cannulae for thoracoscope and cautery
8: Trocar and cannula for Unverricht curved cautery
9: Trocar and cannula for Unverricht straight cautery (Unverricht now has a flexible cannula for either straight or curved cautery)
10: Cannula for ventilating smoke from pneumothorax
11: Forceps for excising tissue for biopsy

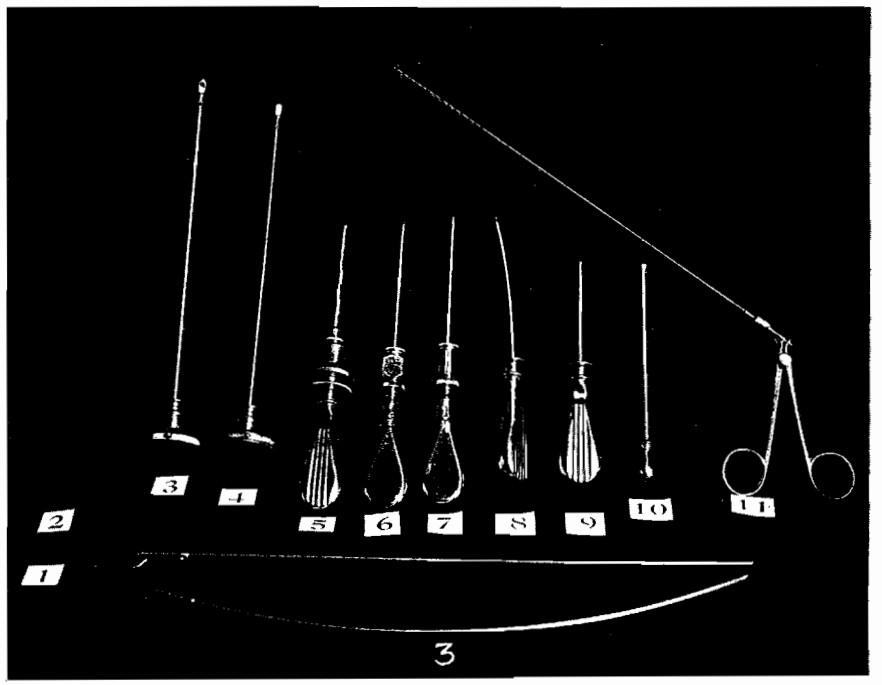


PLATE 2

PLATE 3

Fig. 4. Posterior view of patient draped for introducing the thoracoscope through the posterior chest-wall and the cautery through the lateral chest-wall

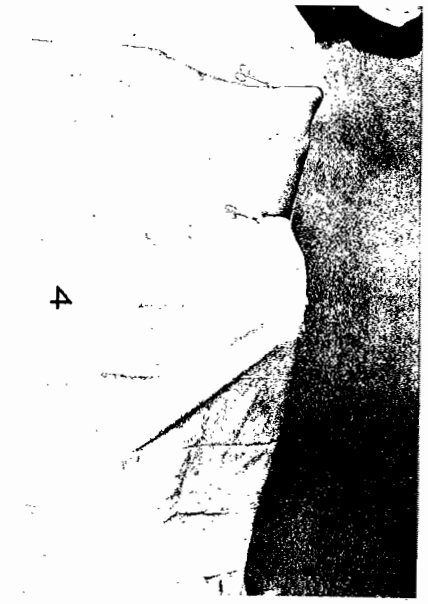
Fig. 5. Anterior view of patient draped for operation, as shown in fig. 4

Fig. 6. Introducing the trocar and ball-valve cannula for the thoracoscope through the posterior chest-wall

Fig. 7. Examination of the pneumothorax cavity with the thoracoscope preliminary to introducing the active electrode or cautery

PLATE 3

4



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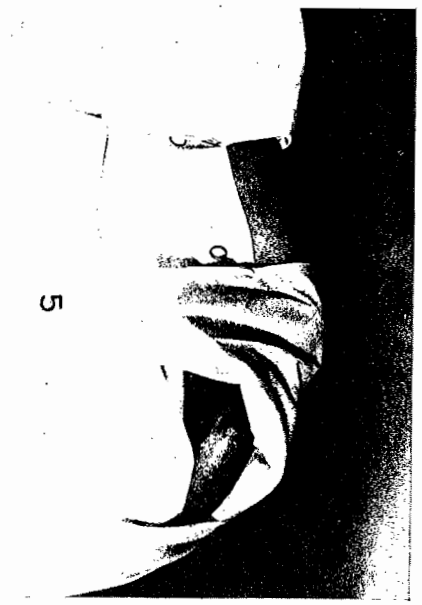


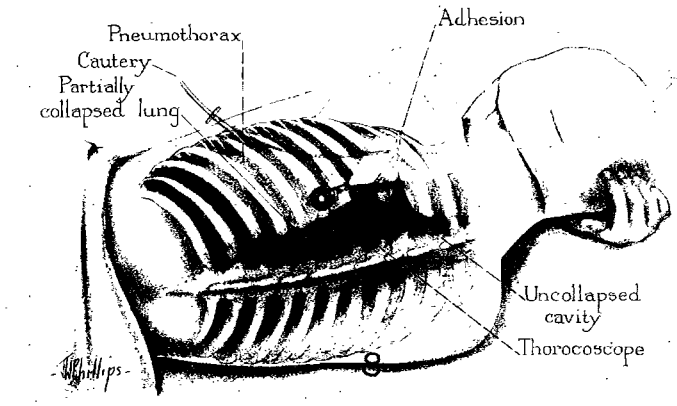
5

PLATE 4

Fig. 8. Diagram of pneumothorax with string-adhesion preventing collapse of a cavity, and showing proper position of thoracoscope and active electrode or curved cautery

Fig. 9. Diagram showing partial pneumothorax with broad band-adhesion at base and multiple string-adhesions preventing collapse of two cavities in the lung

The point of entrance of the thoracoscope is proper, but the cannula for the cautery is shown introduced too low, as the broad band-adhesion prevents its visualization through the thoracoscope



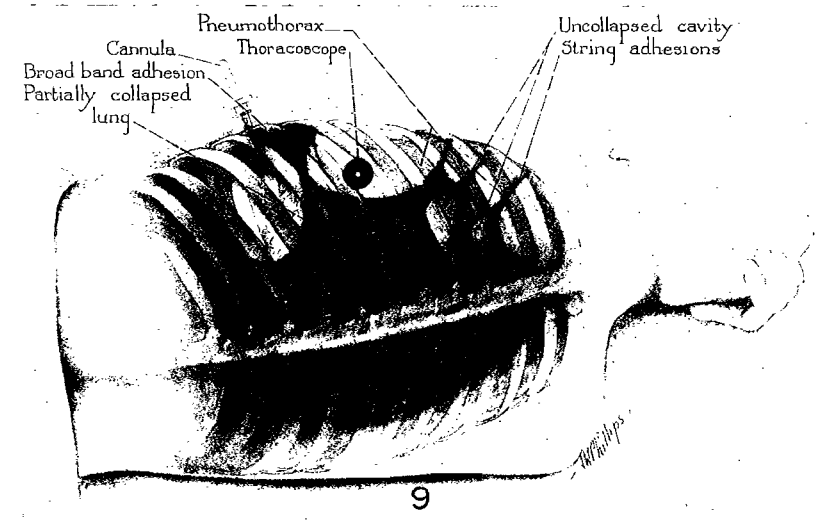


PLATE 4

PLATE 5

Fig. 10. Thoracoscope and active electrode in position for cutting adhesions in the posterolateral aspects of the pneumothorax

1: Active electrode for endothermic cutting of adhesions
2: Flexible cannula
3: Thoracoscope
4: Ball-valve cannula for the thoracoscope
5: Wappler-Wyeth endotherm

PLATE 5

PLATE 7

Fig. 12. Author's electrodes for cutting adhesions by the endothermic method and for electrocoagulation before cutting

1 and *2:* Curved electrodes

3: Straight electrode

4 and *5:* Blunt electrodes for exploring the nature of folds and large bands and for diathermic coagulation of tissue containing blood-vessels before cutting

6: Trocar for introducing flexible cannula

7: Flexible cannula

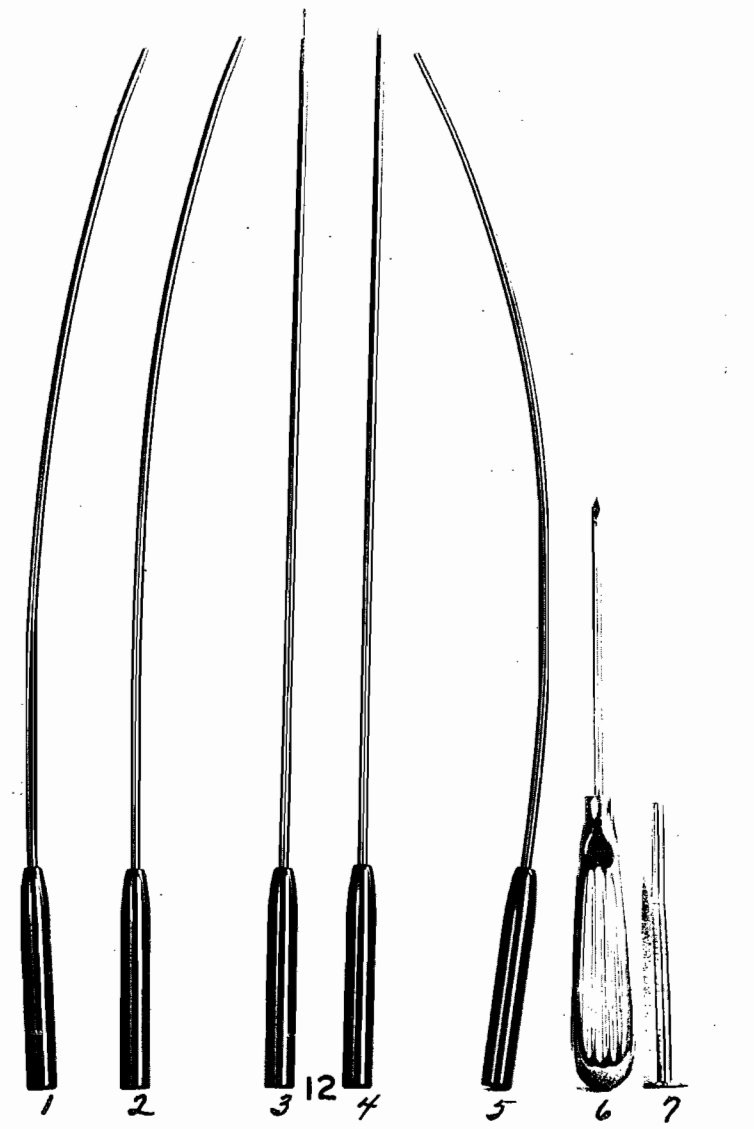


PLATE 7

PLATE 8

Fig. 13. After cauterization of a string-adhesion, too rapid collapse of the lung by large refills of air caused kinking of the drainage bronchus of a large cavity, resulting in retained sputum

1: Cavity

2: Retained sputum

Fig. 14. Same case as fig. 13. Fifteen days after aspiration of air to slightly expand the lung and establish drainage, followed by small frequent refills of air and gradual collapse. Cavity not visible in anteroposterior position in spite of daily average expectoration of 8 cc. of sputum

Fig. 15. Same as fig. 14. Anterolateral view showing uncollapsed cavity not visualized on anteroposterior films

1: Cavity

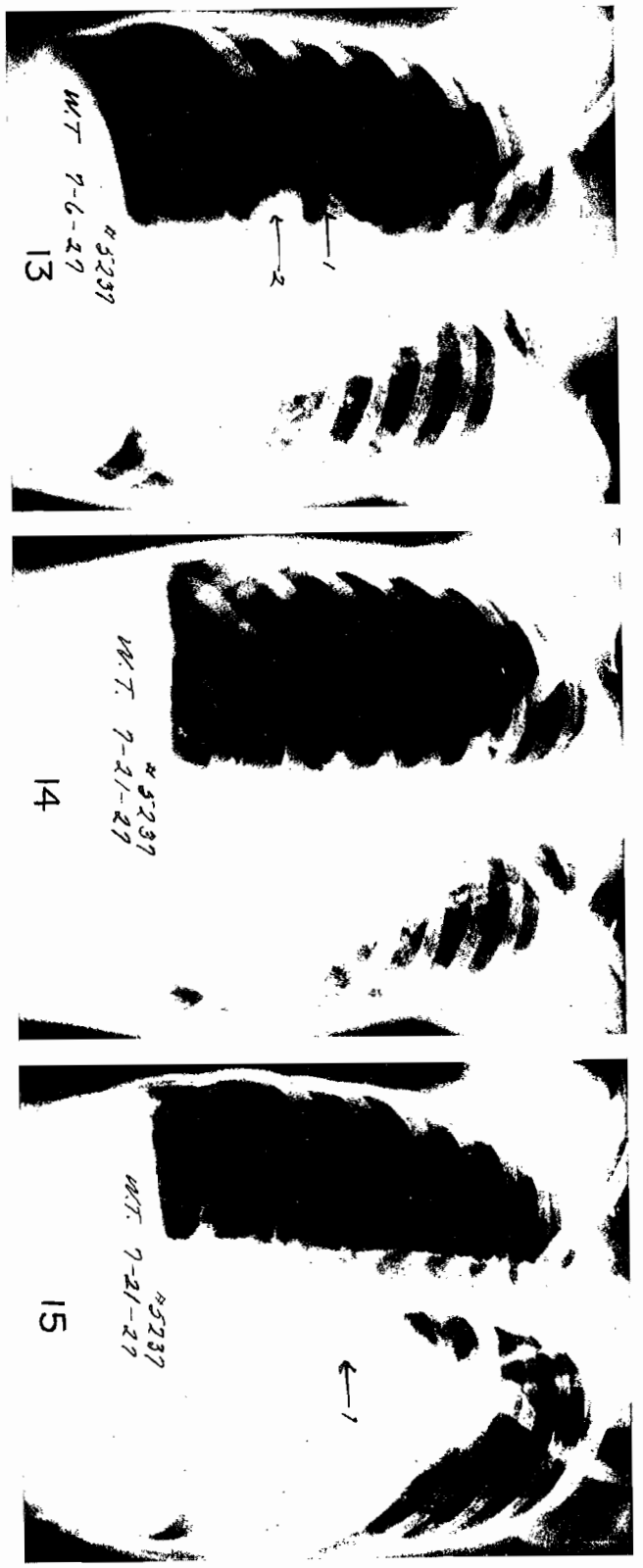


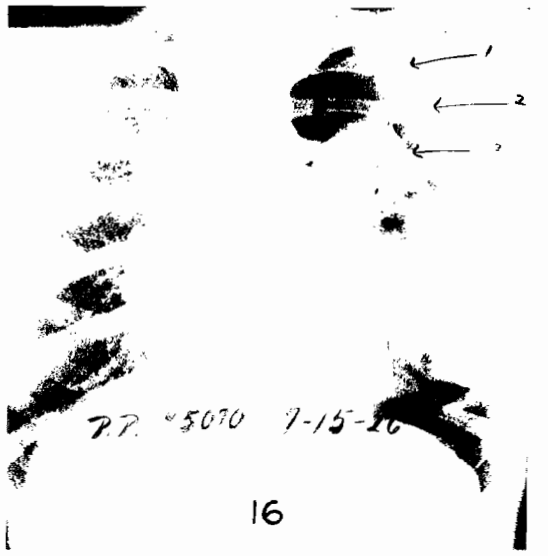
PLATE 9

Fig. 16. Case 5070. Female; age 21 years; sick eighteen months; pneumothorax three months. Average quantity of sputum in 24 hours, 30 cc., tubercle bacilli positive. Temperature, 100° to 101°F.

1 and *2:* String adhesions

3: Uncollapsed cavity

Fig. 17. Case 5070. Approximately six weeks later. Sputum 25 to 30 cc. in 24 hours, tubercle bacilli positive. Temperature 99° to 100°F. One string-adhesion preventing collapse of cavity (*2*) before cauterization. The other string-adhesion, shown in fig. 16 and not visualized on this film, was found on thoracoscopic examination to have been stretched out into a very slender tenacious string



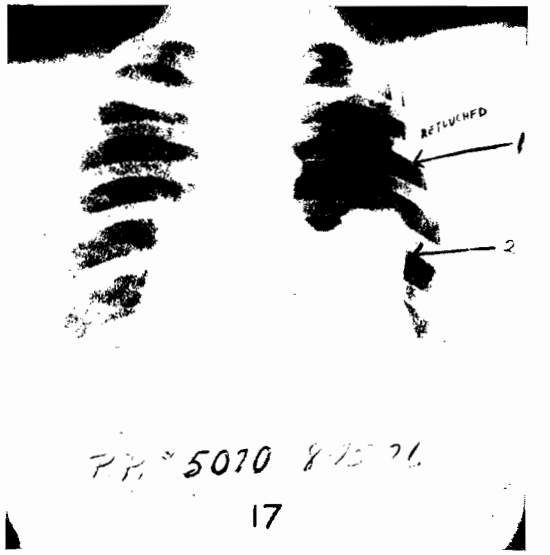


PLATE 9

PLATE 10

Fig. 18. Case 5070

1: Thoracoscopic view of the single string-adhesion shown in fig. 17. *a:* Adhesion. *b:* Periosteum of rib. *c:* Internal intercostal muscle

2: Thoracoscopic view of cautery tip (*d*) on adhesion, coagulating the tissue by using the flat surface to obliterate blood-vessels before burning

3: Thoracoscopic view of cutting the adhesion

4: Retraction of the pulmonary stump of the cut adhesion

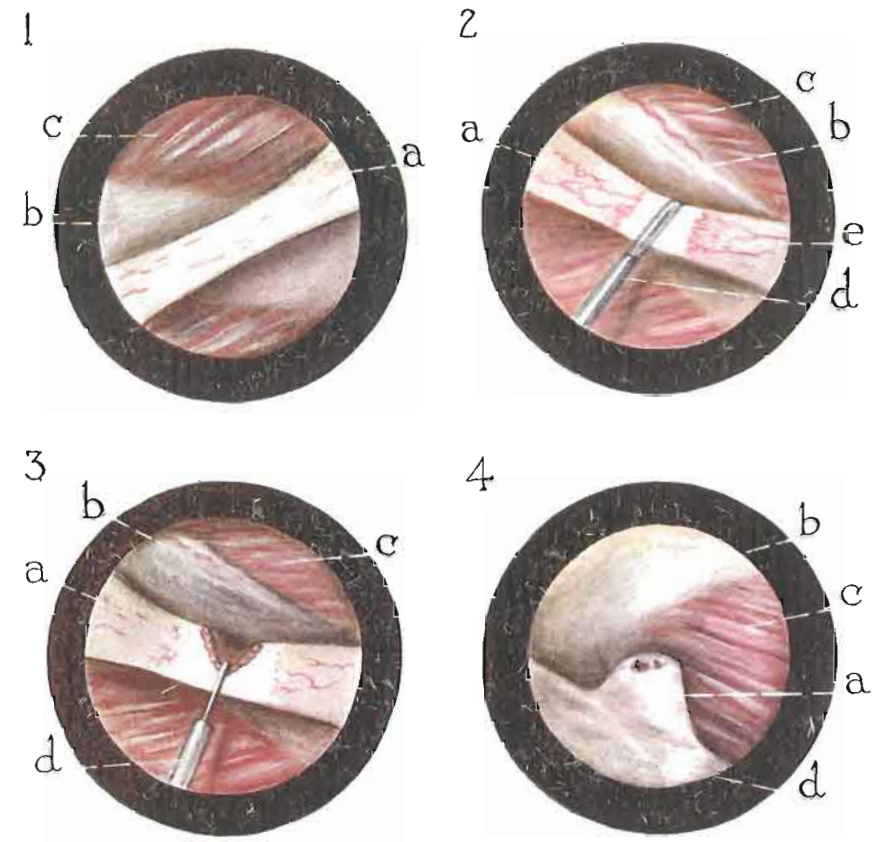


Fig. 18

PLATE 10

PLATE 11

Fig. 19. Case 5070. Two days after cauterization of string-adhesion showing uncollapsed thick-walled cavity (*1*)

Fig. 20. Case 5070. One month after cauterization. Sputum 6 cc. in 24 hours, tubercle bacilli positive. Cavity (*2*) nearly closed

Fig. 21. Case 5070. Nine months after cauterization. Sputum absent for six months. Patient ambulant with satisfactory pneumothorax and without sputum two years and three months later

This is an example of a rigid-walled cavity requiring constant attention to gas refills necessitating gradual collapse. Sputum disappears slowly because of difficulty in collapsing the rigid-walled cavity

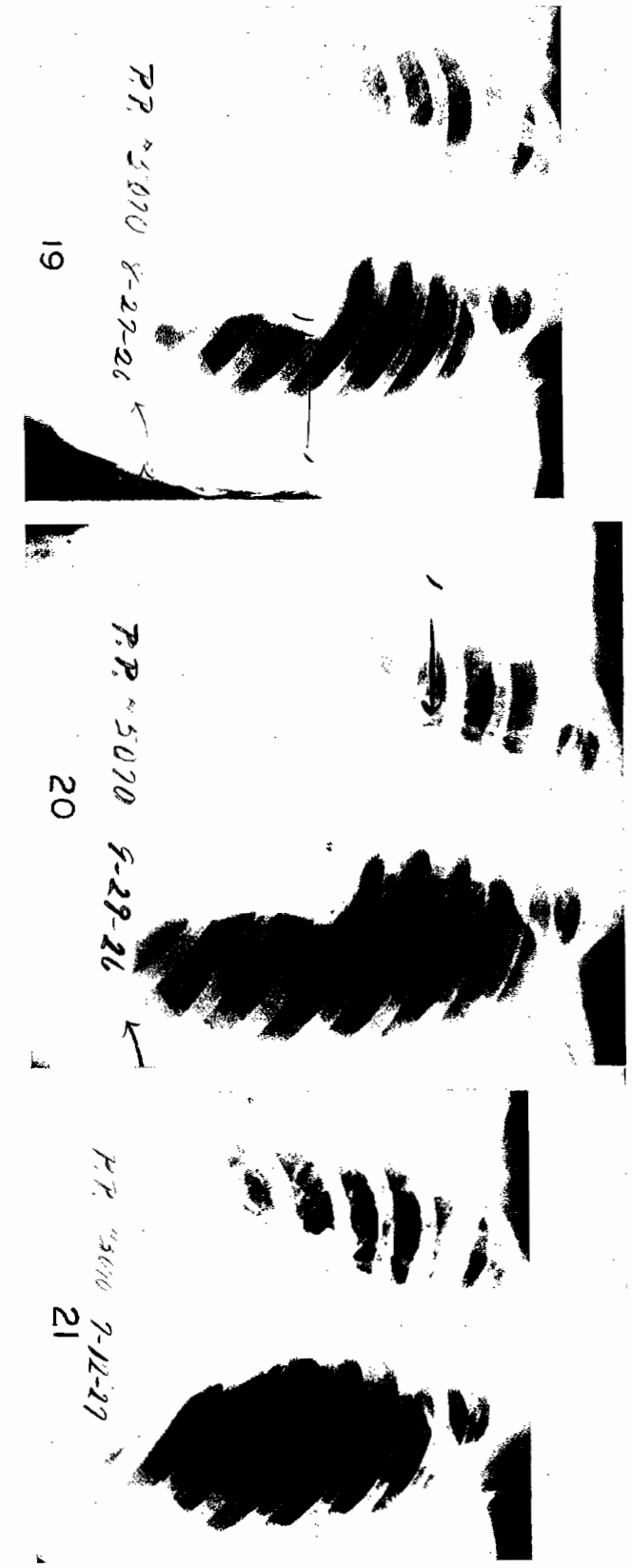


PLATE 11

PLATE 12

Fig. 22. Case 4085. Female; age 18 years; sick five months; loss of weight, 30 pounds; temperature 100° to 101°F.; sputum 30 cc. in 24 hours, tubercle bacilli positive. Large cavity in apex

Fig. 23. Case 4085. One month later with pneumothorax three weeks. Sputum 25 to 30 cc., tubercle bacilli positive; temperature 99° to 100°F.

Fig. 24. Case 4085. Pneumothorax four months. Sputum 20 cc., tubercle bacilli positive; temperature 99.4°F.

1: Band-adhesion at apex

2: Uncollapsed cavity

Cauterization indicated because of stationary quantity of sputum

Fig. 25. Case 4085. Five weeks after cauterization. Sputum 0 to 3 cc., tubercle bacilli negative; gain in weight 8 pounds; temperature normal. Patient ambulant with negative sputum two and a half years since cauterization

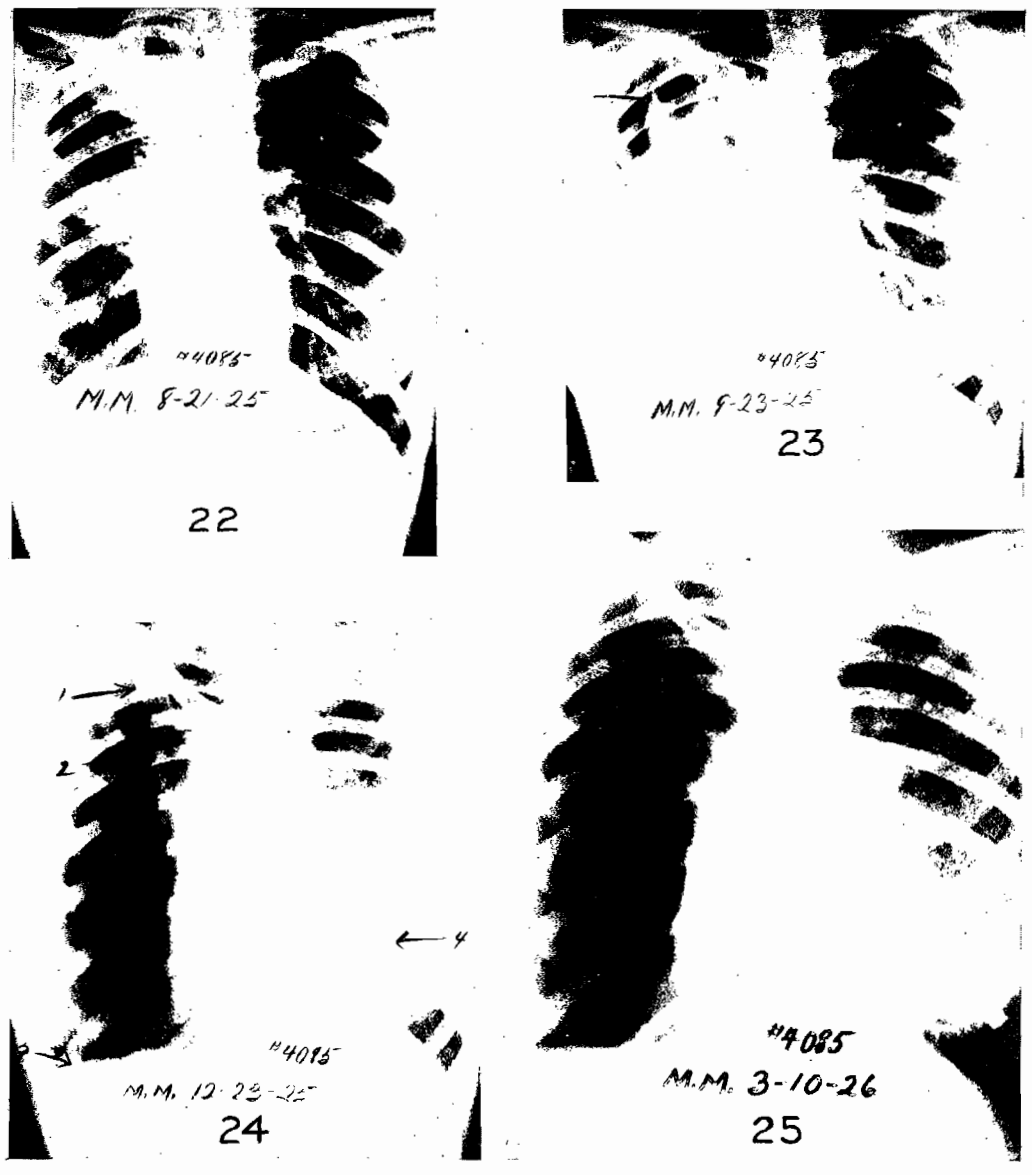


PLATE 12

PLATE 13

Fig. 26. Case 5157. Female; age 30 years; sick six months; sputum 20 cc. in 24 hours, tubercle bacilli positive; weight 120 pounds; temperature 101°F.

Fig. 27. Case 5157. Pneumothorax five months. Sputum 28 cc. in 24 hours, tubercle bacilli positive; weight 139 pounds; temperature normal
1: Adhesions preventing collapse of the lung
2, 3 and *4:* Displacement of diaphragm, mediastinum and heart. Cauterization indicated because of stationary quantity of sputum

Fig. 28. Case 5157. Seven days after cauterization. Sputum reduced to 5 cc. in 24 hours, tubercle bacilli positive; seven days later sputum denied

Fig. 29. Case 5157. Two months after cauterization. No sputum; temperature normal; weight 152½ pounds. One and one-half years later patient working, but still under pneumothorax and without sputum

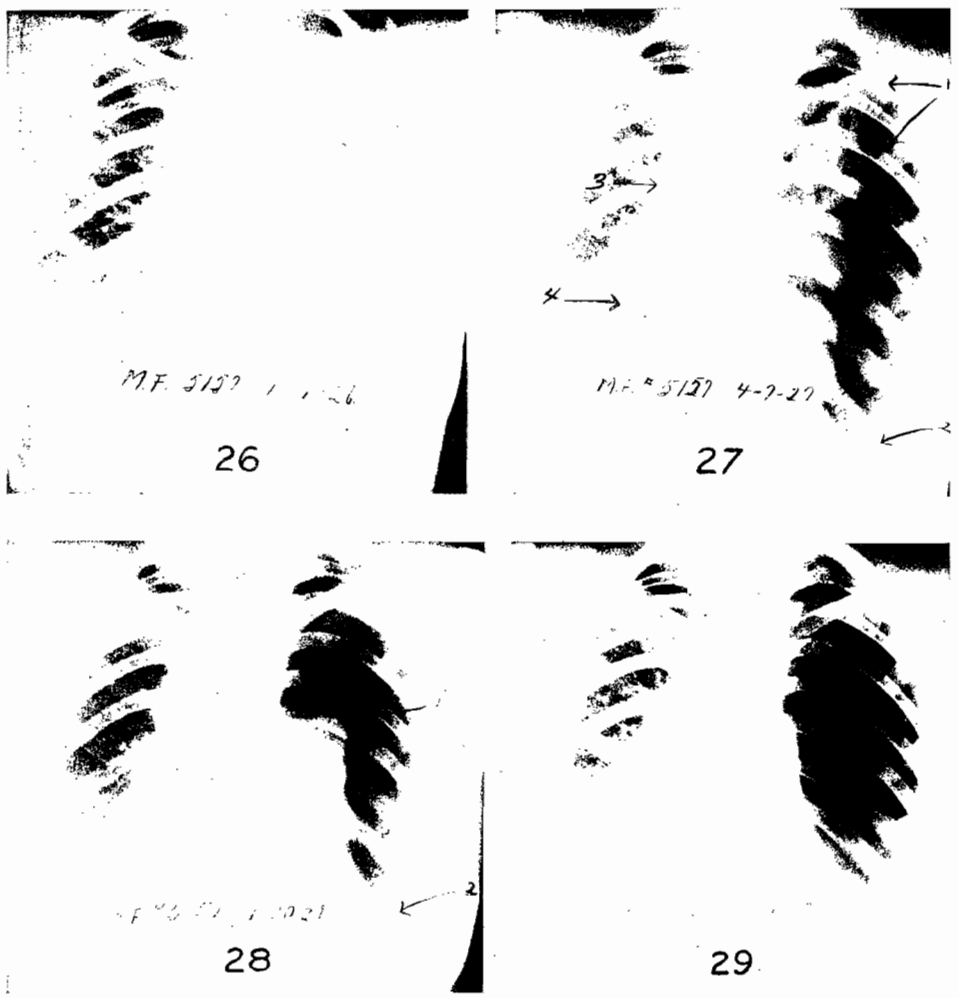


PLATE 13

PLATE 14

Fig. 30. Case 5246. Female; age 37 years; sick eight months; temperature 100° to 102°F.; loss of weight 15 pounds in spite of three months' bed-rest; sputum 26 cc. in 24 hours, tubercle bacilli positive

Fig. 31. Case 5246. Pneumothorax four months. Sputum reduced to 15 cc., tubercle bacilli positive; temperature 100°F.; constant loss of weight due to anorexia and pressure ~~pneumonia~~ phenomena; distressing cough followed gas refills
1 and *2:* String-adhesions preventing collapse of lung
3: Mediastinal displacement
Cauterization indicated because of uncomfortable pressure symptoms

Fig. 32. Case 5246. Four days after cauterization. Sputum denied; temperature normal in two weeks; gain in weight and disappearance of anorexia followed at once after cauterization. Nine months later patient still free from sputum

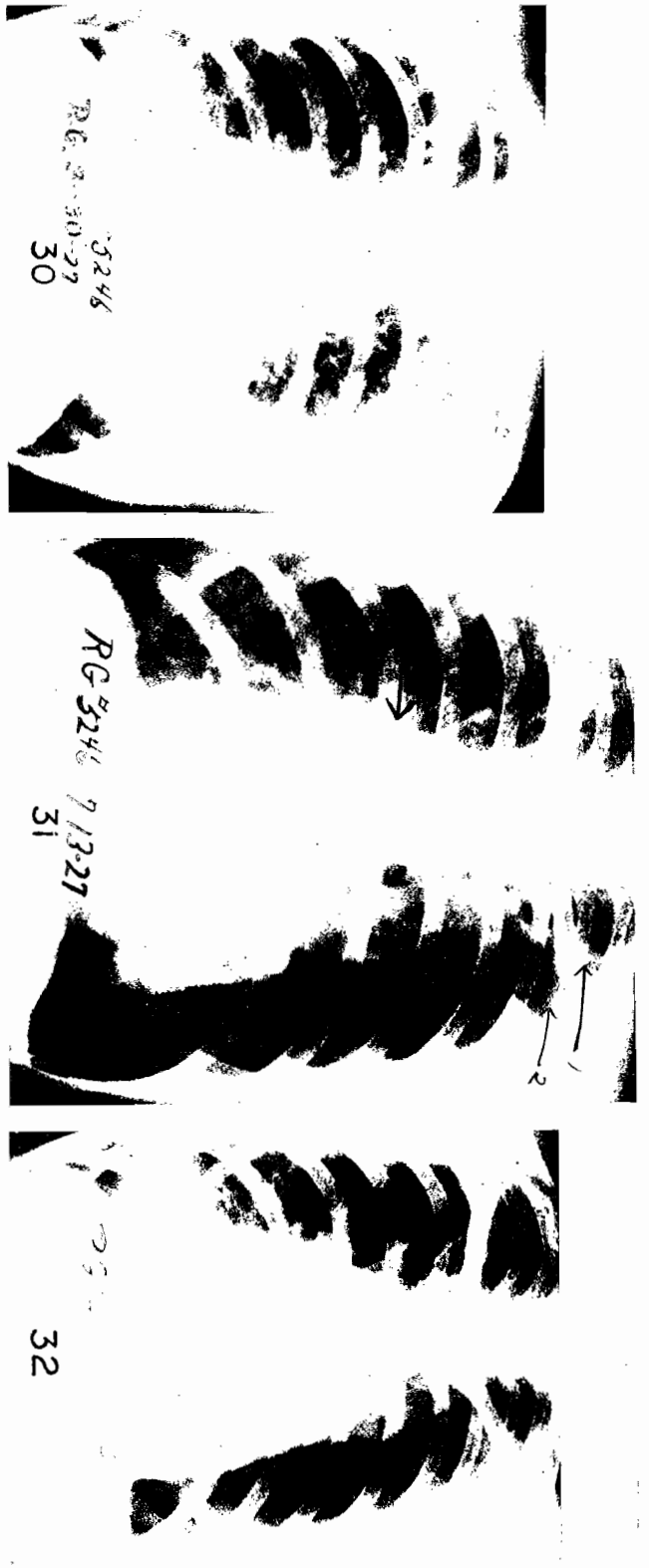


PLATE 14

PLATE 15

Fig. 33. Case 5308. Male; age 26 years; pneumothorax treatment four years. Tuberculous pyothorax last two years. Sputum became negative for tubercle bacilli after six months' pneumothorax treatment and remained negative one and one-half years; then became positive, with repeated haemoptysis, the past two years. Average 24-hour quantity of sputum, 15 cc.

1 and *2:* String-adhesions expanding the collapsed lung

3: Purulent exudate

Fig. 34. Case 5308. Two days after cauterization of adhesions and injection of 250 cc. 5 per cent oil of gomenol. Sputum 10 cc., tubercle bacilli positive

1 and *2:* Chest-wall stumps of adhesions

3: Oil of gomenol

Note improved collapse of lung

Fig. 35. Case 5308. Two and one-half months after cauterization. No sputum; no further haemoptysis. Complete collapse of lung. Oil of gomenol in pneumothorax space, 750 cc. One year later patient is working; no further haemoptysis; no sputum. Oleothorax being continued

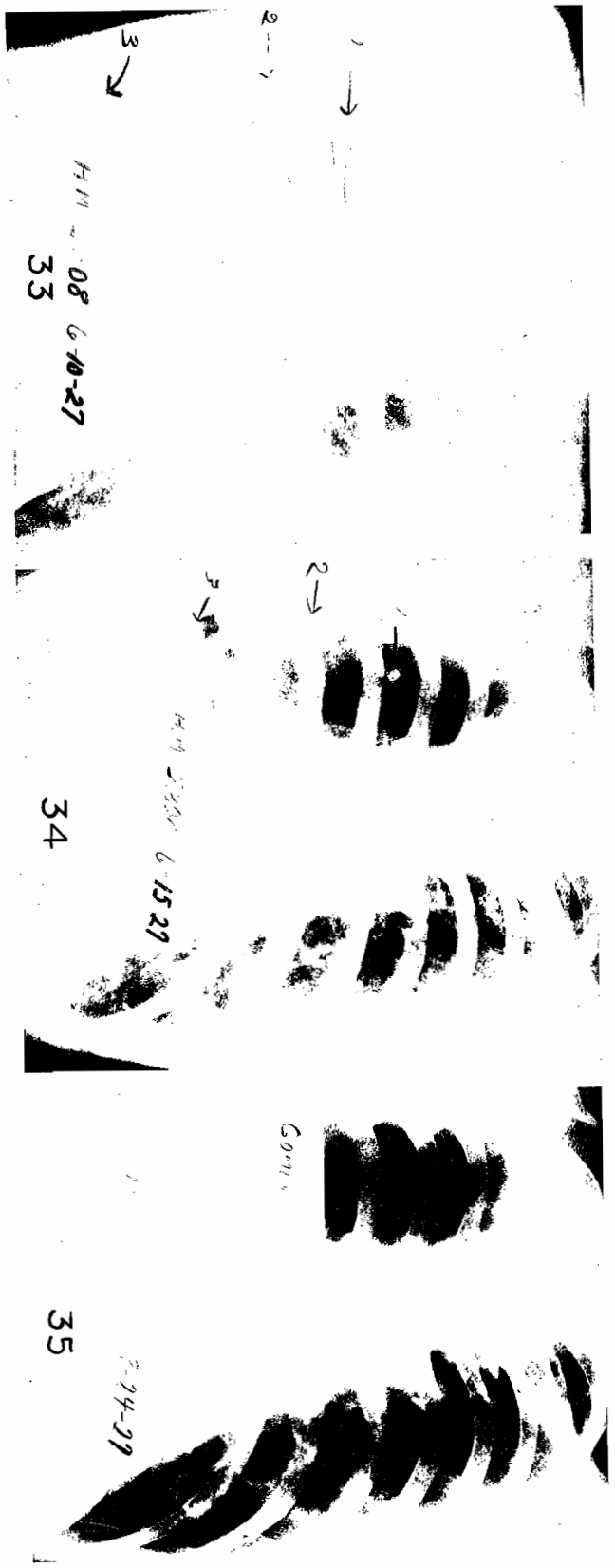


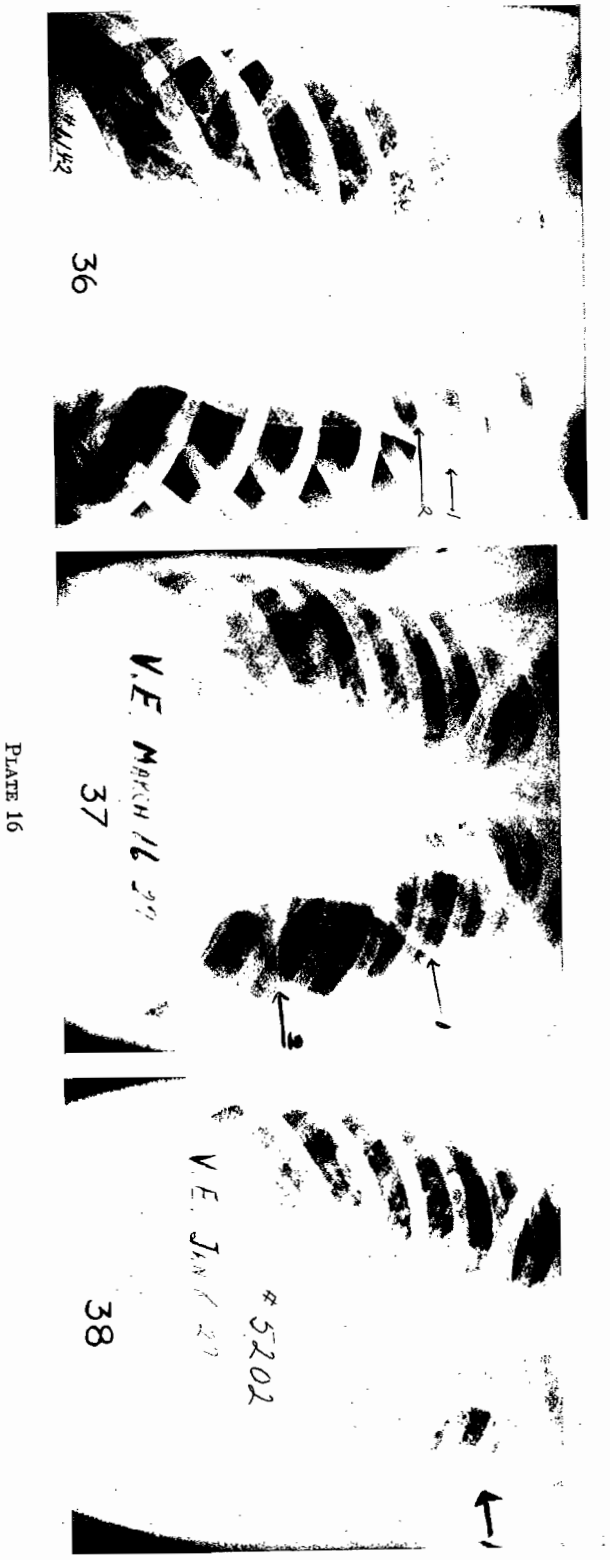
PLATE 15

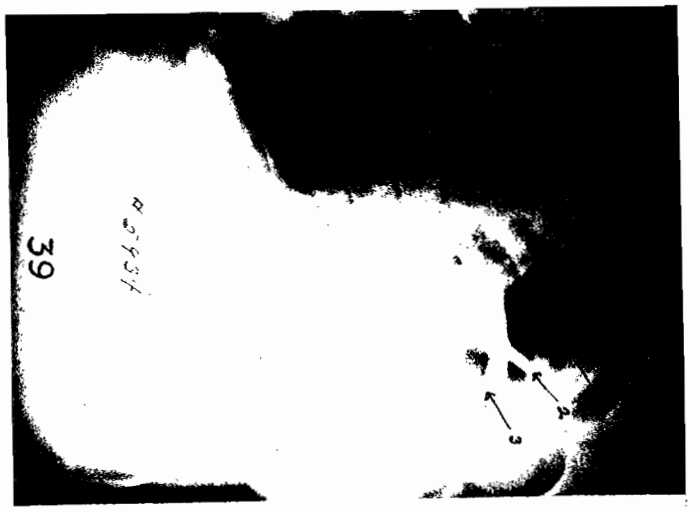
PLATE 16

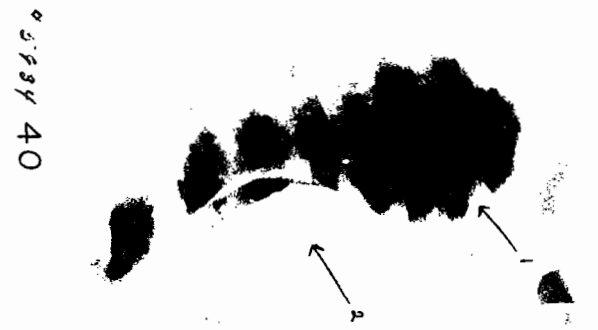
Fig. 36. Case referred for cauterization of band-adhesion at *1* supposedly holding open a cavity (*2*). Original films not available at the time. Thoracoscopic examination revealed *1* to be the floor of another uncollapsed cavity. Later study of the original film showed two large cavities in the upper lobe of the left lung

Fig. 37. Case 5202. Apparently a broad band-adhesion (*1*) preventing collapse of the lung. *2:* Slender band-adhesion at the base. Twenty-four-hour quantity of sputum, 50 cc., suggesting utilization of cauterization

Fig. 38. Case 5202. Original film of same patient shown in fig. 37. Average quantity of sputum for 24 hours, 80 cc. Comparison of the two films suggests that what appears to be a band-adhesion in fig. 37 is the floor of the cavity shown in fig. 38. Thoracoscopic examination confirmed this opinion







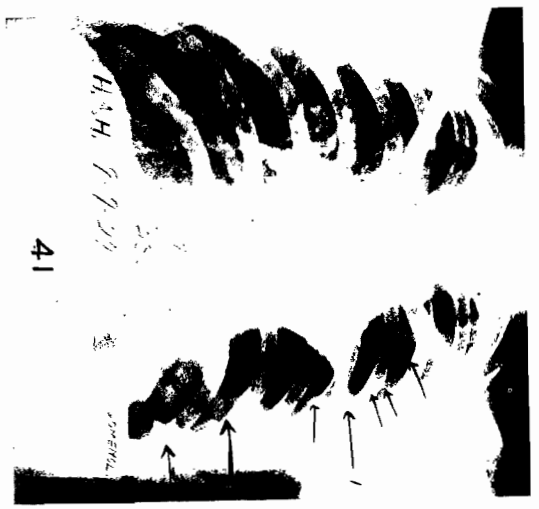


PLATE 17

Fig. 39. Case referred for cauterization of a band-adhesion. The two fluid levels shown on the film were thought to be fluid in two pneumothorax compartments
1: Supposed upper compartment
2: Supposed band-adhesion
3: Supposed lower compartment

Fig. 40. Posterior view of same case, showing 20 cc. lipiodol injected into the pneumothorax cavity below, and the patient filmed with head down. The lipiodol remains confined in the lower compartment
1: Uncollapsed cavity
2: Lipiodol in pneumothorax

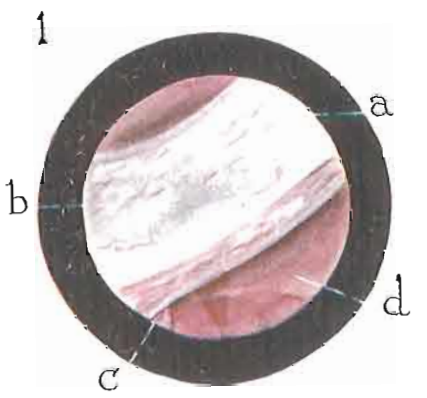
Fig. 41. Case 5334. Apparent band-adhesion (*1*) between a partially collapsed lung and lateral chest-wall. Referred as appropriate for cauterization. Thoracoscopic examination revealed a fold-adhesion, with thick anterior edge, extending around the posterior wall of the pneumothorax cavity to lateral wall. Numerous very slender string-adhesions were present at points indicated by arrows. *XX* indicates the attachment of the lung to the posterior wall of the pneumothorax. A thick fold-adhesion is shown at *2* and a thick band at *3*. Case unsuited for cauterization

PLATE 18

Fig. 42. Thoracoscopic view of a diffuse fold-adhesion

1: Diffuse fold-adhesion between lung and lateral chest-wall with thick anterior edge which appeared as a string- and band-adhesion on the X-ray film. Its dark gray color at *b* on thoracoscopic examination suggested either lung tissue or increased thickness of the adhesion

2: After cutting the free edge, an additional dense fold containing lung tissue (*b*) was found extending to the posterior wall of the pneumothorax space and not suited for cauterization. Cutting the free edge permitted the remaining portion of the adhesion to stretch, improving the collapse. A partial thoracoplasty was then done. The patient is clinically well



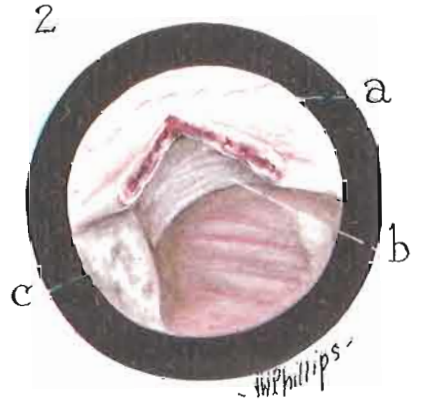


Fig. 42

PLATE 18

PLATE 19

Fig. 43. Case 6093. Female; sick one year; sputum 40 cc. in 24 hours, tubercle bacilli positive; afternoon temperature 100° to 101°F.

Fig. 44. Case 6093. Pneumothorax six weeks. Sputum 25 cc. in 24 hours; afternoon temperature average 100°F.
1, 2, 3 and *4:* String- and band-adhesions
5 and *6:* Tuberculous cavities

Fig. 45. Case 6093. Pneumothorax two months and immediately after cutting adhesions posteriorly at *1* and *4*. Cavity *5* is smaller, but *6* uninfluenced. Average quantity of sputum in 24 hours, 20 to 25 cc.

Fig. 46. Case 6093. Pneumothorax nine weeks and immediately after second cutting of adhesions anteriorly. Small cavity shown at *5*, fig. 44, is collapsed but the large cavity has been uninfluenced
1 and *2:* Represents the shadow of what appeared as a fold of pleura extending from the lung across the posterior wall of the pneumothorax space

Fig. 47. Case 6093. Twenty cubic centimetres of lipiodol were injected into the pneumothorax cavity and its movements studied under the fluoroscope while the patient stood upright. The patient was then placed upon the fluoroscopic table and the head of the table slowly lowered to a horizontal position. The film was taken in the latter position

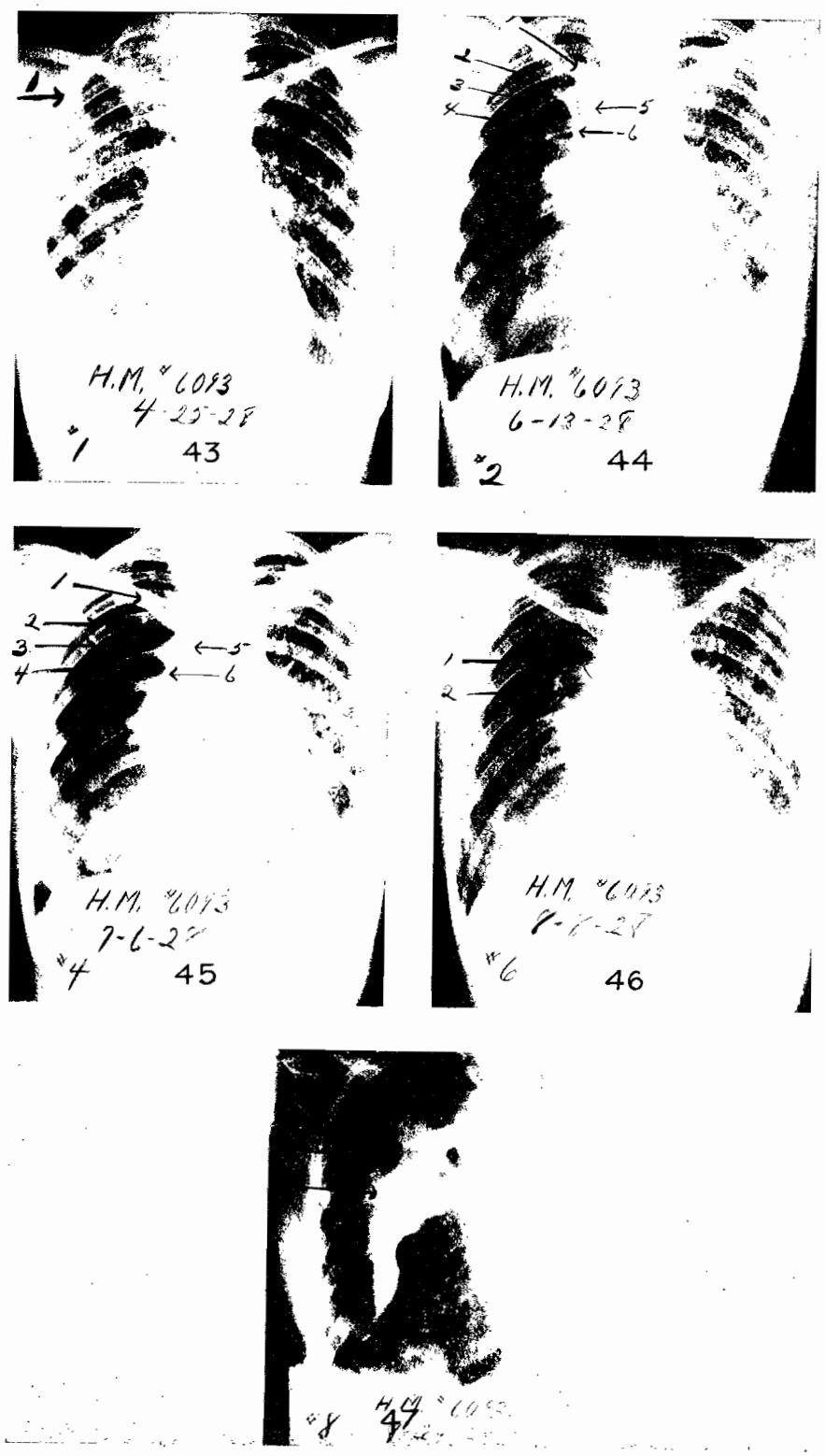


PLATE 19

PLATE 20

Fig. 48. Case 6093. Thoracoscopic view of adhesion shown in fig. 46 (*1* and *2*)
a: Chest-wall attachment
b: Upper lobe of right lung
c: Lower lobe of the right lung
d: Intercostal muscle
e: Rib

Fig. 49. Case 6093. Thoracoscopic view of adhesion, showing use of author's blunt electrode for purposes of exploring nature of tissue before cutting. This instrument is also used for electrocoagulation of tissue, to obliterate large blood- and lymph-vessels before cutting

Fig. 50. Case 6093 Thoracoscopic view of adhesion shown in fig. 46 (*1* and *2*) after cutting with endothermic electrode
a: Lung stump
b: Chest-wall stump

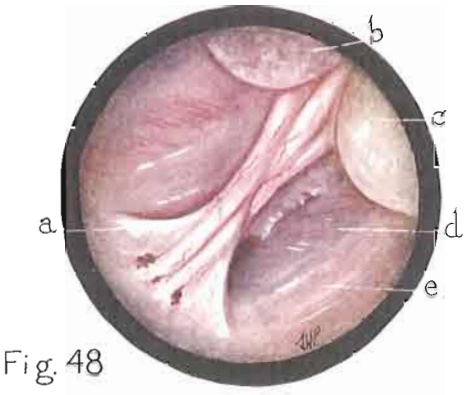


Fig. 48

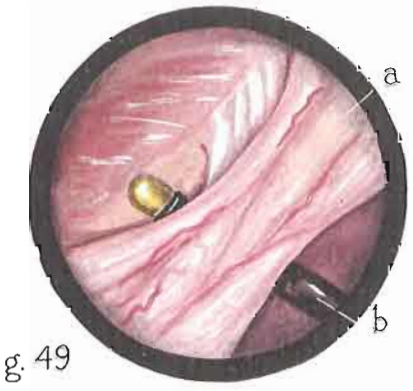


Fig. 49

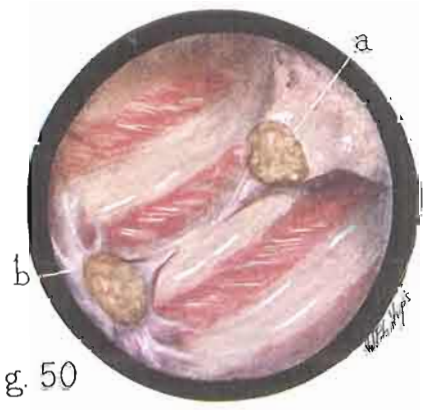


Fig. 50

PLATE 20

PLATE 21

Fig. 51. Case 6093. At once, after third cauterization, note improved collapse of cavity, *3*

1: Chest-wall stump of adhesion

2: Small fold of pleura of no technical importance, which extended from the adhesion shown in fig. 48 to the posterior chest-wall

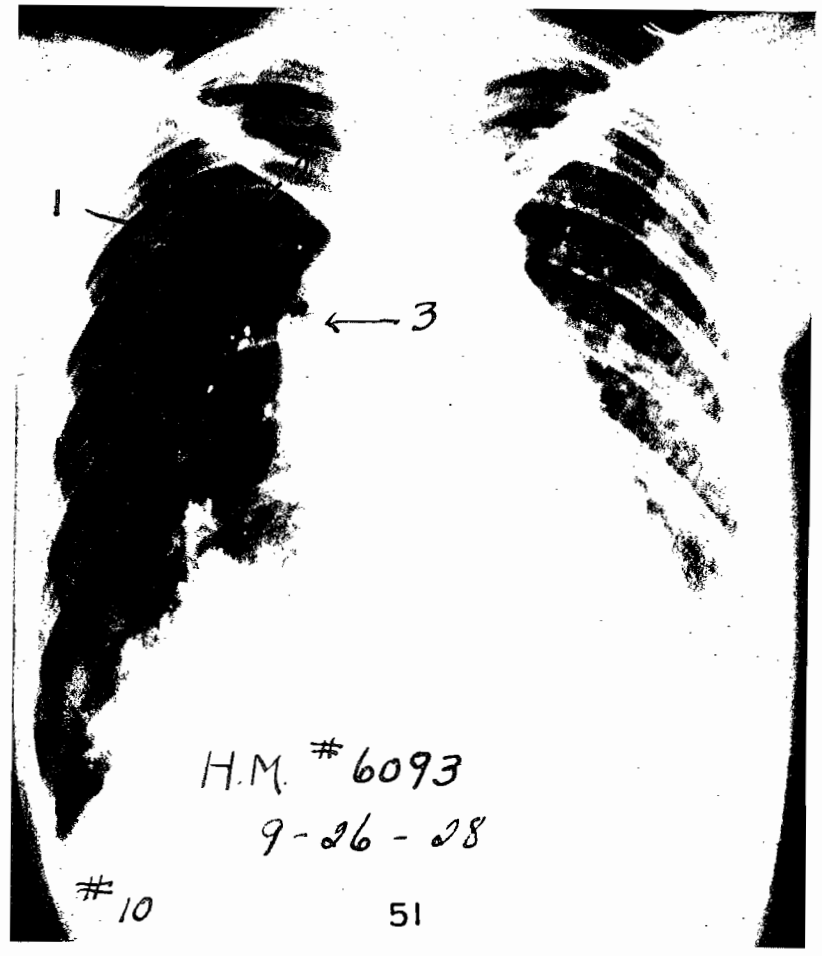


PLATE 21

PLATE 22

Fig. 52. Case 6172. Female; sick one and one-half years. Large tuberculous cavity in the upper lobe of the right lung (*1*) with bronchogenic dissemination to opposite side (*2*). Sputum 40 cc., positive for tubercle bacilli

Fig. 53. Case 6172. Pneumothorax five weeks. Cavity (*1*) collapsing away from chest-wall. No adhesions visible, but suspected because the pulmonary collapse and intrapleural pressure following subsequent inflations were not in proportion to the amount of air injected. Sputum 30 cc.

Fig. 54. Case 6172. Pneumothorax seven weeks after large refill of air. Stereoscopic films revealed apparent string-adhesions at *1* and *3*. Uncollapsed cavity (*2*). Quantity of sputum, 30 cc., only slightly influenced by pneumothorax

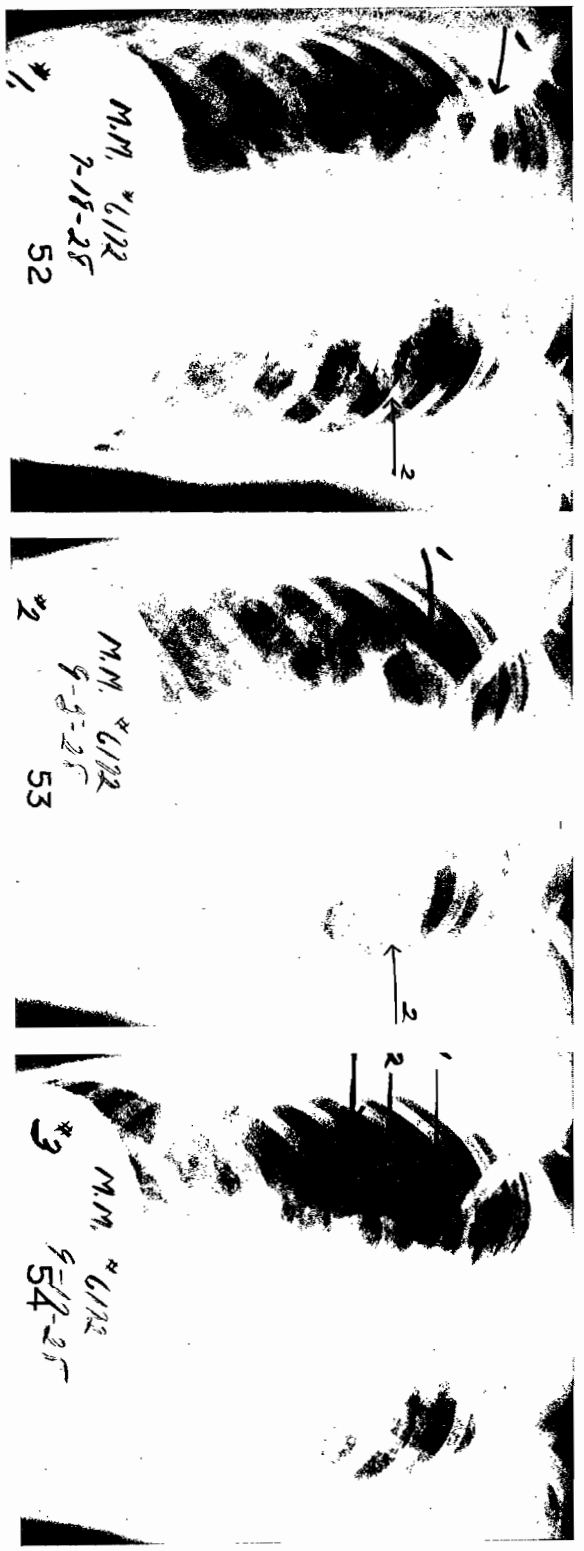


PLATE 22

PLATE 23

Fig. 55. Case 6172. Thoracoscopic view of a string-adhesion, 5 mm. wide, shown in fig. 54, extending from the upper lobe of the right lung near the interlobar fissure to the lateral chest-wall

a: String-adhesion
b: Middle lobe
c: Upper lobe
d: Caseous tubercles at the base of the adhesion

Fig. 56. Case 6172. Thoracoscopic view of apex of right lung

a: Fan-shaped adhesion extending from the apex to just above the sternal end of the first rib. This adhesion appeared as a mere string (*1*) on the film shown in fig. 54

b: The blue line near the border of the adhesion (*a*) suggested the presence of a blood-vessel

c: Superior vena cava, 2.5 cm. distant from the adhesion

d: Lung

e: Intercostal vein

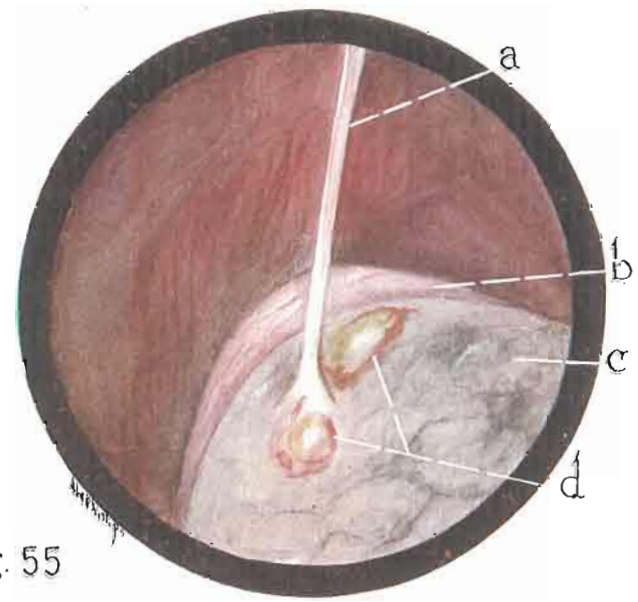


Fig. 55

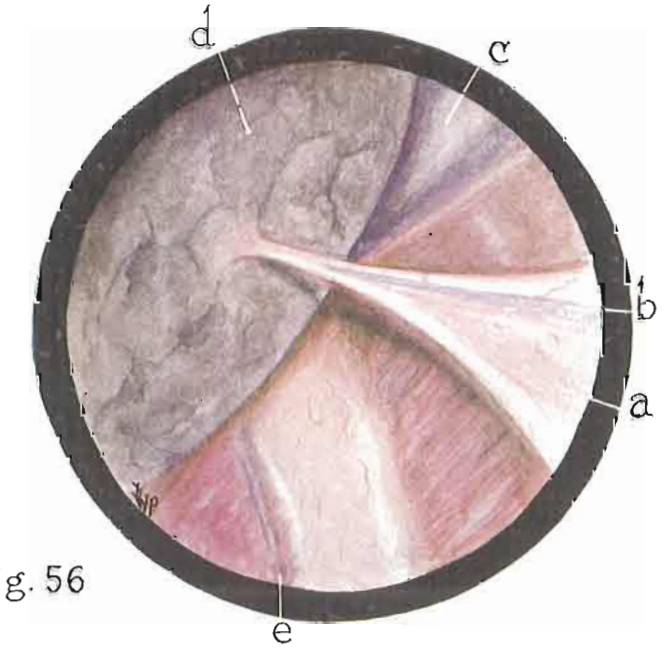


Fig. 56

PLATE 23

PLATE 24

Fig. 57. Case 6172. Method of examining structure of adhesion with author's blunt electrode *c*. The blue line, *b*, suggesting the presence of a blood-vessel, proved to be merely a very thin part of the adhesion as shown by its transparency

Fig. 58. Case 6172. Thoracoscopic view of adhesion cut by endothermy
a: Chest-wall stump
b: Lung stump
c: Lung

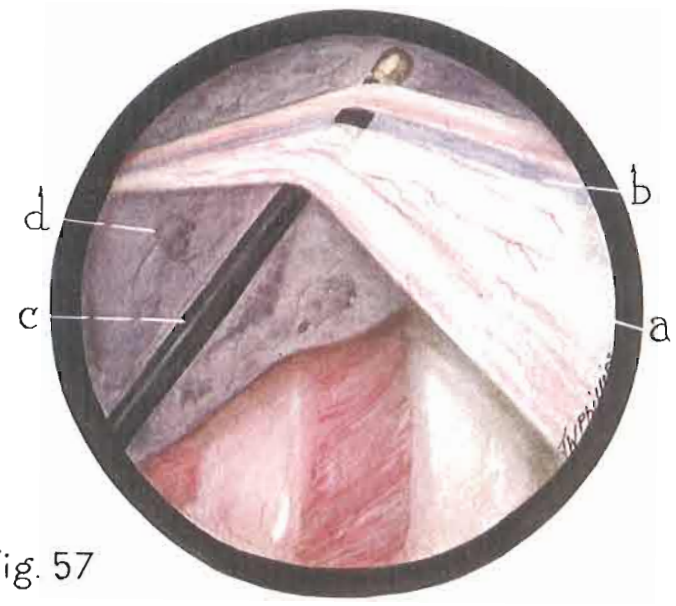


Fig. 57

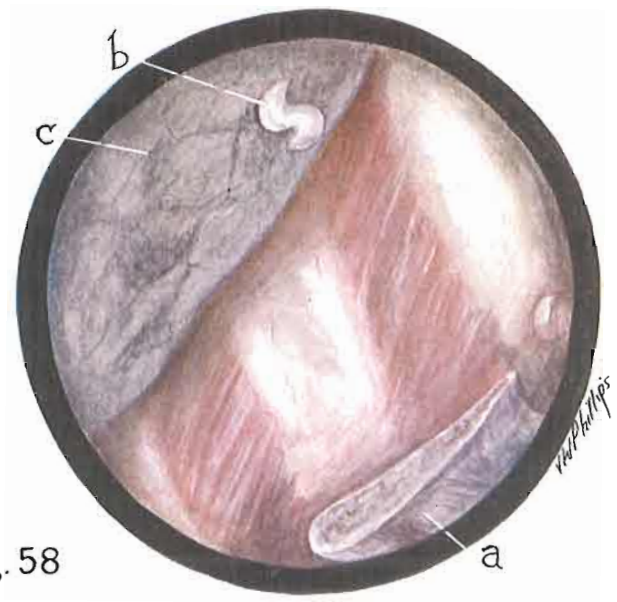


Fig. 58

PLATE 24

PLATE 25

Fig. 59. Case 6172. At once, after cutting adhesions shown in fig. 54. Note increased collapse of cavity (*1*). One week after cutting adhesions the sputum was reduced to 5 cc. in 24 hours

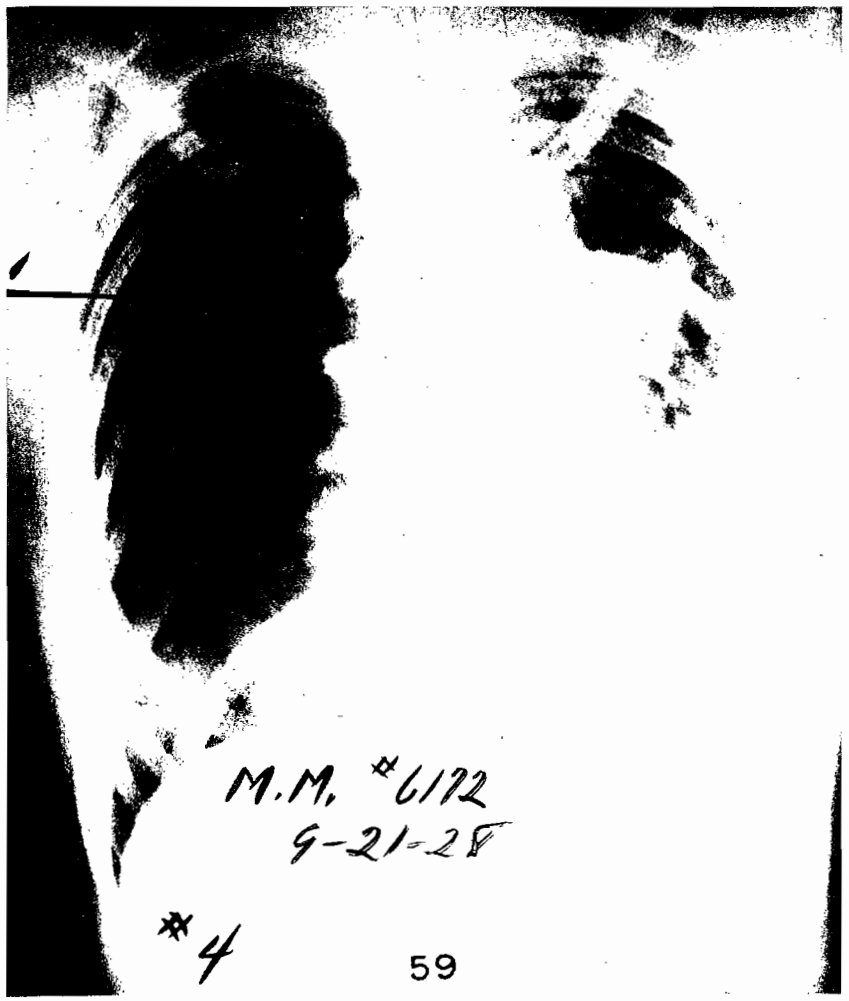


PLATE 25

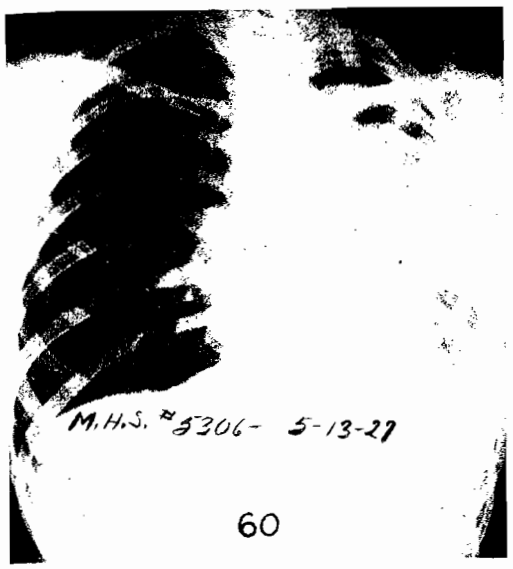
PLATE 26

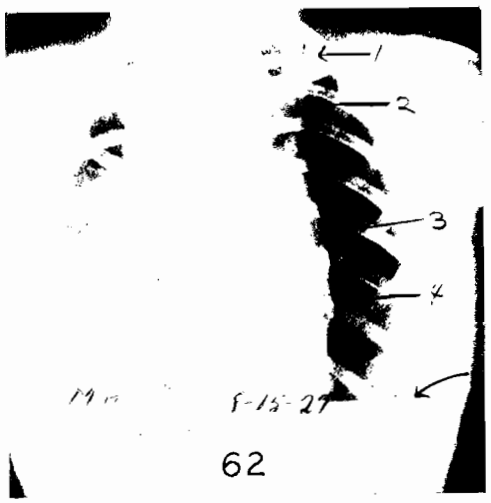
Fig. 60. Case 5306. Female, age 28 years; sick one year; sputum 160 cc., tubercle bacilli positive; temperature 100° to 101°F.; weight 116 pounds. Large cavity in apex with multiple cavitation in upper and lower lobes of left lung

Fig. 61. Case 5306. Pneumothorax two months. Sputum 60 cc., tubercle bacilli positive; temperature normal; weight 118 pounds. Uncollapsed large apical cavity, with three smaller uncollapsed cavities. Multiple string- and band-adhesions at *1, 2, 3, 4* and *5*

Fig. 62. Case 5306. Six days after cauterization of adhesions at *2, 3, 4* and *5*. Apical adhesion not cauterized because of presence of lung tissue close to chest-wall. Sputum reduced to 25 cc. Temperature normal. Ten days later sputum was reduced to 10 cc. daily

Fig. 63. Case 5306. Four months after cauterization. Sputum still absent nine months after operation. Remaining apical adhesion not interfering with collapse of lung





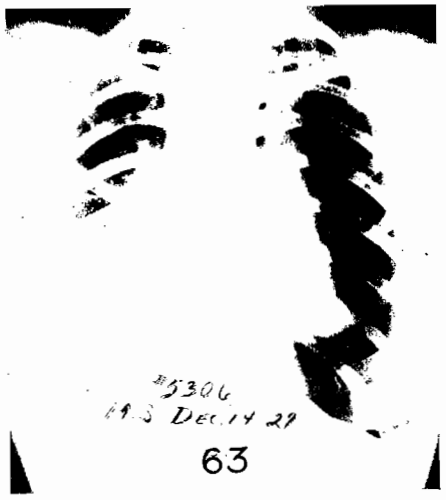


PLATE 26