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THE HUMAN RESPONSE TO FLYING STRESS*

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LECTURE I: NEUROSIS IN FLYING PERSONNEL

Historical

When Dr. James Birley (1920a) gave the Goulstonian Lectures twenty-three years ago on Medical Science and Aviation he described in words which have lost none of their freshness and vigour the picture of what he called flying stress, and because this term has been widely employed I shall begin by explaining the sense in which Birley used it and the change of meaning that has since taken place. Birley and his colleagues were confronted with the twofold problem of studying, first, the unknown factors of stress to which the airman was exposed, and, secondly, the effects of this stress upon the human organism. Unfortunately, as so often happens in the study of functional nervous disorder, the distinction between causes and symptoms was in the end ignored, and "flying stress," which was appropriately coined for the load which the airman had to carry, was later used to describe the state of ill-health which resulted when this load was too heavy. Flying stress, in fact, became a clinical diagnosis.

The implication that the occupation of flying had resulted in a new disease found ready acceptance not only because the occupation was so new and so dramatic but because there seemed evidence that lack of oxygen, which at that time was inevitable in high flying and unknown in any other occupation, could cause functional nervous disorder of a widespread and long-lasting kind. It was certain, at any rate, that a person actually suffering from anoxia showed psychological disorder as well as other symptoms. It was assumed that repeated exposure to anoxia might lead to persistent effects of the same kind. Thus Flack (1920), who was one of the pioneers in aviation medicine, attributed nervousness, insomnia, lack of confidence, and disinclination to fly to this cause. Birley (1920b) soon became suspicious of this opinion, for he observed these symptoms in men who had not flown at high altitudes. He suggested that the cause in these cases was occupational fatigue. The position of flying stress as an occupational disease was thus upheld. Later, however, he noted that the same symptoms might be seen in men who had neither flown at high altitudes nor flown long enough to suffer from cumulative fatigue. He observed that in this group there was often a family or personal history of neuropathy, and suggested that here there was temperamental unfitness "which," he said, "lies largely in an undue susceptibility to mental shock, to which these individuals react primarily by various mental and psychical phenomena and secondarily by various alterations in their physical state."

How far this last observation has been confirmed and extended during the present war I shall hope to show. I may anticipate now by saying that there is no more warrant for

the use of "flying stress" as a term of clinical diagnosis than there was for "shell-shock," which, it was agreed by the War Office Committee (1922) appointed to inquire into the subject, was wholly misleading, "and should be eliminated from official nomenclature, the disorders hitherto included under this heading being designated by the recognized medical terms for these conditions." The objection to the use of "flying stress" as a diagnosis of course applies equally to other terms such as "aeroneurosis" and "aviator's neurasthenia." All are founded upon error, and might well—as shell-shock did—have become a danger to morale. "Flying stress" should be used only to denote the load which air-crews have to carry. For the ill effects which may result in some persons from overloading, terms of ordinary clinical usage will suffice.

Scope and Methods of Present Investigation

In our study of functional nervous disorder in flying personnel during the present war we began with certain advantages. Before long the apparatus for maintaining oxygen supply at heights had been so perfected that it was usually possible to exclude anoxia as a causal factor unless there was evidence that the apparatus had not been properly used or had gone wrong. Our view of the neuroses also was broader and deeper than had been possible 25 years ago. Our approach to the problem rested upon the belief that the symptom pattern or reaction type of a neurosis cannot be related to any single cause—that an anxiety state, for example, may have as its main cause emotional conflict, infection, or exhaustion; and that, standing between environmental stress and symptom pattern, individual constitution is all-important.

At the direction of Air Marshal Sir Harold Whittingham, for some time all cases of neurosis in flying personnel have been analysed on the basis of data collected by the neuropsychiatric specialists of the Royal Air Force. The inquiry was restricted to cases seen by the specialists, with the knowledge that this would exclude some of the milder cases; but the restriction was necessary to obtain data of consistent value, and it is certain that almost all flying personnel in this country and in the Middle East in whom there was any question of unfitness for full duty on account of functional nervous disorder were seen by the specialists, and are included in this investigation. The specialist fills in a card for every case seen, sending it to a central registry, where the data are extracted. The information recorded in addition to the particulars of the man's service, flying hours, and tactical duties includes the reaction type of the illness and the main causal factors. Three further questions are set. One is concerned with flying, and is in two parts. First, Has the illness arisen from *flying duties*, and, if so, what were the incidents responsible? Second, What was the weight of *flying stress* to which the patient had been subjected? Our instructions on this point are that the assessment of flying stress as *nil*, slight, moderate, severe, or exceptional should be made in relation to the average load carried by healthy persons in this occupation. The problem was not whether the man in question had had to carry more than he could manage, but whether the load had been greater than.

* Based upon the Dunham Lectures at Harvard University, March, 1943, and the Croonian Lectures before the Royal College of Physicians of London, May, 1943.

that which the ordinary man could take. The next question asks for an estimate of *non-flying stress*—for example, domestic worries—as *nil*, moderate, or severe, with relevant data. The last requires an estimate of *predisposition* to functional nervous disorder as *nil*, moderate, or severe, again with supporting data if the assessment is positive. The agreed criterion for severe predisposition is that the specialist considers that if he had seen the man as a candidate for air-crew he would have advised rejection. A few case summaries will illustrate the nature of the material collected.

Cases Illustrative of Predisposition and Stress

Case 1: Sgt. X., pilot, aged 23; flying hours, 190; operational hours, *nil*.—His father had suffered from an obsessional neurosis, and he himself had been away from school for six months at the age of 9 owing to what he described as "a mania for tapping things and screwing his eyes up." He always tended to worry unduly over small things. He had no unpleasant experience in training or any personal worries, but when he began flying Hudsons the noise of the engine, he said, "got on his nerves." He could think of nothing else, and developed headache and insomnia. This is a straightforward example of an obsessional neurosis in a man who would never have been accepted for air-crew had his history been disclosed. Although flying duties had contributed to the breakdown, flying stress was *nil*. Non-flying stress was also *nil*. Predisposition was severe.

Case 2: Fl. Lt. Y., D.F.C.; pilot, aged 23; flying hours, 600; operational hours, 120 in day bombers (25 sorties).—This officer presented with headache, insomnia, anxiety, depression, and loss of confidence for flying. There was no evidence of neurotic predisposition. He had gone through an operational tour with distinction at a time when casualties were heavy. He then married and had been flying on instructional duties for a year. His symptoms developed when he himself was unfit (a fortnight convalescent from appendicectomy) and his child died suddenly. The neurosis (anxiety and depression) was not considered attributable to flying duties. He was a man who had been submitted to a slight degree of flying stress. Predisposition was *nil*, non-flying stress severe.

Case 3: P/O Z., G.M.; pilot, aged 27; flying hours, 240; operational hours on day bombers, 100.—This officer had since childhood been unduly sensitive to slights, easily depressed, and lacking in confidence. His squadron suffered heavy casualties, and eventually he was wounded in the leg on a sortie over the North Sea. He flew his damaged aircraft home, but it blew up on landing. He won the George Medal for pulling his air-gunner out of the blazing wreckage. After two months in hospital he was physically fit to fly, but was tense, anxious, depressed, and self-reproachful. The illness here was clearly attributable to flying duties. Flying stress was rated as severe. Predisposition was moderate, non-flying stress *nil*.

Case 2 is representative of a group in which the neurosis, though resulting in incapacity for flying duties, was due to causes unrelated to flying. Excluding this group and confining our attention to neuroses which have arisen from flying duties, we have asked ourselves among other questions what are the important factors in causation, how the neurosis develops, and what are the commonest reaction types. With this purpose the data recorded on a consecutive series of 2,000 cases have been analysed, and as a separate investigation representative station and squadron commanders as well as medical officers in the Training and home-based Operational Commands have been interviewed by Squad. Ldr. Denis Williams and myself and asked these two questions: "What are the things which get men down?" and "How do you know when a man has had enough?" It was hoped that this inquiry, systematically developed, would give us a better idea both of causes and of early symptoms than can be obtained from the evidence of men who have developed a neurosis. Actually it did more than this, for many of the 200 flying personnel interviewed volunteered accounts of their own reactions to stress. Such introspective material furnished by distinguished officers of great experience has been a valuable addition to our knowledge. The records of cases of neurosis seen personally have provided an additional source of information. Some of the conclusions reached by these means will be briefly presented.

Distribution and Causes of Neurosis

There has been no difficulty in the classification of cases under the ordinary clinical headings. Anxiety states occurred in 79% of the cases, depressive states in 9%, and hysteria in 13%; mixed forms were not infrequent—hysteria, for example, being often grafted upon an anxiety state. Our

tables, which cannot for Service reasons be published now, show that the incidence of neurosis in different tactical duties varies directly with the amount of hazard encountered, as measured by the casualty rates. It is thus lowest in Training Command, highest in night bombers. In duties which involve long trips with relatively little hazard the incidence of neurosis is low, suggesting that emotional tension is a more important factor than physical or skill fatigue. That skill fatigue is probably an operative factor is shown by a rather higher incidence in pilots than in all other members of air-crew taken together; but the highest for a specific duty is among rear gunners of heavy bombers, where skill fatigue is negligible but emotional tension high. Although causal factors of a physical kind have been systematically inquired for—exhaustion, air-sickness, altitude effects, cold, physical injury, and illness—they have been recorded in less than a third of the cases, and then generally as subsidiary factors. Altitude and cold were in fact not recorded in any case. By contrast, psychological factors have been present in 99% of the cases.

We have found plenty of evidence to support Birley's suggestion that temperamental unfitness for the job was an important causal factor. More than two-thirds of our cases show what he referred to as a family or personal history of neuropathy, which in this investigation we have called predisposition to neurosis. These men are vulnerable to stress, and the severely predisposed often break down over flying duties without being exposed to any flying stress as judged by average experience. At the other extreme stress may be severe enough to cause a breakdown in men with no predisposition. In the intermediate group the inverse relationship between flying stress and predisposition is striking, so that it can be stated that the more flying stress a man has experienced before breaking down the less evidence of predisposition will be found in his history.

Percentages of Patients with Varying Predisposition exposed to Differing Degrees of Stress

Predisposition	No.	Flying Stress					Non-flying Stress		
		Nil	Slight	Mod	Sev.	Exc.	Nil	Mild	Sev.
Nil	604	18	27	33	20	2	62	34	4
Moderate	1,173	30	30	28	11	1	64	33	3
Severe	423	47	32	15	6	0	64	33	3

This table shows that non-flying stress is almost identical in the three groups, and that it is the flying stress which is responsible for the reciprocal relationship between stress and predisposition, since it falls steadily as predisposition increases in the three groups.

As would be expected, the amount of flying stress rises steadily with the number of hours flown, and especially with the number of operational hours. Corresponding with this, our figures show that the more flying experience, and especially the more operational experience, a man has had before breaking down the less likely we are to find predisposition. In fact, the severely predisposed individuals tend to break down relatively early in their flying career, leaving those with less or with no predisposition either to succeed or to break down later as the result of greater experience and greater stress.

Among the cases in which the neurosis was mainly attributable to flying duties, factors included under non-flying stress had contributed in 36%. These factors might of course be physical or psychological, but were in fact almost always the latter and usually arose from domestic anxiety. In this connexion it has been of interest to observe that the incidence of non-flying stress is higher in married than in single men, and that among operational air-crew it has been highest in the Middle East Command, doubtless owing to the anxieties inseparable from prolonged service abroad.

In our assessments of predisposition we have been guided by the principles of general clinical experience and by the special experience of flying personnel who have broken down. The importance of family and personal history in relation to the risk of neurosis under conditions of active service has received attention in papers published during the present war by Curran and Mallinson (1940), Hadfield (1942), Love (1942), and Cooper and Sinclair (1942). Gillespie (1942) has emphasized the frequency in childhood of a history of specific tendencies indicating timidity and lack of aggressiveness in flying personnel who have developed neurosis under the strain of flying duties, and our joint experience has confirmed the value of his

observations. As an example the avoidance of diving by a practised swimmer is evidence of a kind of timidity often found in the past history of those with neurosis. The validation, by follow-up, of the prognostic value of such traits is likely to be of practical value for selection. We do not know yet what is their distribution among those who succeed. We have nevertheless some ground for belief in the practical value of our criteria, for the investigation of unselected air-crew by the same methods and by several observers working independently has shown the incidence of predisposition to be four and a half times lower than among those who have broken down.

The quantitative assessment of the abstraction flying stress proved less difficult than was anticipated. Its success is shown by the striking uniformity of the percentage of cases recorded as exposed to the different degrees of stress in the various operational commands, and the consistency of assessments made independently on the same case by different observers. The specialists had, of course, already had considerable experience of Service flying conditions when the investigation began.

Fear as an Element of Flying Stress

Evidence has already been presented for the conclusion that the most important element of flying stress as a cause of neurosis is exposure to danger. This is confirmed by analysis of the psychological causes which were held responsible in 99% of the cases of the series under review; for the story in most of them is that of a persistent state of fear resulting from either excessive stimulation of this emotion in men without predisposition to neurosis or from a lesser stimulus in the predisposed. This, again, simply confirms previous observation in other combatants (Mapother, 1935; Dillon, 1940; Love, 1942; Cooper and Sinclair, 1942). It is evident, therefore, that in the prevention of neurosis in flying personnel serious consideration should be given to the subject of fear.

Fear is a state of feeling which is only strictly ascertainable by introspection, though it is often associated with behaviour indicating a tendency towards flight and with bodily disturbances which have been extensively studied by physiologists. The objective study of fear can never take us to the heart of the problem, but studies of the reactions of young children to situations of a kind which excite fear in adults are of value in tracing the origins of the fear response. The observations of Valentine (1942) are of especial interest. It appears that there are innate trigger mechanisms which provide for a constant behaviour response to certain stimulus patterns. These triggers, however, are not all present at birth. Most of them mature later. For example, a fear response to the dark was not observed by Valentine before the age of 2, but was of common occurrence at later ages. There is considerable individual variation in the number and selective response of these innate responses. One child, for example, may show fear responses to fewer fear situations than the average; another may show more than the normal sensitiveness to a particular type of situation, such as a moving animal. This last observation is of especial interest in connexion with the specific irrational fears or phobias of adults, which may be associated with relative fearlessness in other directions and appear in some cases to be inherited. Granted these trigger mechanisms, it may be argued that fear responses to more complex situations are built up in the manner of conditioned reflexes. This hypothesis leaves out of account the question of the existence, as a part of the original trigger response, of the affective quality which is fear. Valentine's critical comment deserves quotation. "We can," he says, "only distinguish these responses from mere reflexes by saying that they are at least the first of a series of responses which, remaining and developing within a corresponding series of external conditions, are eventually known by adults to be accompanied by the emotion of fear."

The experimental observation of fear in animals is obviously fraught with greater difficulty, for there is never the opportunity of establishing the association of behaviour with feeling. Nevertheless, as Bard (1939) remarks, we are justified in asserting that a dog or a cat is displaying rage or fear without committing ourselves to the determination of its subjective state. Accepting this limitation, we may take note of the spontaneous display of fear following experimental lesion of

the hypothalamus. Here is evidence suggesting that the affective state of fear may exist independently of any perception or idea of danger. There is clinical evidence to support this. In some cases of affective disorder the patient's complaint is that he feels afraid though there is nothing either in fact or in imagination which should cause this feeling. There is suggestion here of a central mechanism for the generation of affect, which under certain abnormal conditions may result in a fear state arising or persisting without activation by the stimuli which normally excite it.

The observation of bodily changes such as pulse rate or sweating is of little value in ascertaining the presence of fear, for they are common to other emotions. Physiologists in their analysis of these bodily changes have emphasized their value as preparation for adequate response to danger. Less attention has been paid to the psychological value of fear. It is nevertheless widely recognized that fear, within limits, is not only a natural but a healthy emotion, stimulating attention, sharpening judgment, and evoking maximal effort. I have frequently heard the opinion from distinguished pilots that fear in due measure may be a vital asset in reacting to an emergency, whether in flying or in combat, and that the absence of fear in a situation of this kind may be fatal to success.

Fear of course is often felt in the absence of actual danger. The most familiar example is anticipatory fear, or apprehension, either of real or of imaginary dangers. This, again within certain limits, may be valuable. An experienced squadron commander told me that he liked a man to have enough imagination to fear the worst and hope for the best. Thus he would set forth on his operational sortie prepared for every hazard, and would be more likely both to succeed and to survive than the more phlegmatic types. Incidentally, he added that this kind of man, though he was most likely to give good operational service, was most likely to suffer from the effects of stress. Another common and interesting example of fear in the absence of actual danger is that which, after danger is past, may be experienced by an imaginative person when he reflects upon a narrow escape. Here it seems that the magnitude of the impending disaster has been such, or its passage so swift, that full perception is delayed. The more time and opportunity there is for reflection the greater the tendency to the development of this delayed fear reaction. Thus the man who has been hurt in a flying accident and lies idle may be at a disadvantage by comparison with his comrade who after the same accident remains on duty, his mind occupied with other matters. This does not mean that retrospective fear is inappropriate or unhealthy. On the contrary, it may be of value in pointing experience. The fighter pilot if he has the right spirit gains in value from a narrow escape in combat. Fear within certain limits is a stimulus; only when it exceeds these limits is it a weakness.

The persistence of fear after danger is past is not always to be explained by reflection and rumination, for it may be recognized by the subject as irrational. Mosso (1896) observed this point. After a fear response which has been due to misinterpretation of a situation the individual discovers his mistake and is glad; yet the "perturbation and oppression do not at once subside, but continue to annoy for some time. They are like the continued vibration of a cord that has been shaken—like the echo of a sound reverberating in the nervous fibres and slowly dying away." This tendency for fear to persevere may be observed in many persons if the stimulus has been violent; but in relation to stimuli of average intensity it is remarkable in certain individuals, suggesting an innate propensity to react in this manner.

I have referred to the value of fear as a stimulus within certain limits. It is necessary now to define these limits. They are set by standards determined not only by the needs of the individual but also by those of his social unit. For both these needs it is essential that emotions other than fear should have free play—anger and loyalty, for example. It is when fear dominates the mind to the exclusion of other emotions that it becomes harmful. "The phenomena of fear, which may be useful in lesser degrees, become morbid and fatal to the organism as soon as they exceed a certain limit: for this reason fear must be looked upon as a disease" (Mosso). For the combatant group, whether air-crew, ship's company, or

platoon, fear in excess is of course a deadly disease—so much so, that during the last war it must be camouflaged and called "wind up." The ancients also felt it necessary to disarm fear, and used their conventional method of appeasement. Alexander of Macedon offered up sacrifices to Fear before he went into battle. In Naples there are two Roman medals, one of which bears the impression of a terrified woman, the other of a man with hair on end and staring eyes. They were struck in fulfilment of the vows made by the Consuls before a certain battle to propitiate fear, which threatened to invade the ranks of the soldiers, who after this measure had been taken were led to victory. It is interesting to observe, in the books and plays already produced by the present war, frank reference to fear, and to speculate upon the reasons which have allowed this. Whatever these may be, for us who study flying stress it is an advantage to discard the old convention and to admit fear in excess as the kernel of our problem. As Mosso remarks in his spirited introduction to this subject: "The time has come when we must throw off our professorial robes, tie on our aprons, roll up our sleeves, and begin the vivisection of the human heart according to scientific methods."

Although fear is frankly admitted by flying personnel individually in their published records of combatant experience, and in serious discussion of flying stress, official documents in the flying Services speak not of fear but of lack of confidence. Doubtless there is here an underlying preference for meiosis, but there is more in the term than this. It implies the lack of a virtue rather than the presence of a vice. Confidence is a positive quality of inestimable value to the airman. Without it he can never achieve outstanding success, and despite every effort he is likely to succumb sooner or later to the effects of flying stress. Lack of confidence is a major cause of flying accidents, operational failures, and psychological breakdown in air-crews. What, then, is meant by confidence? It is, I believe, compounded of if not identical with fearlessness, and will be the subject of my next lecture.

(Lecture II, with the full list of references, will appear in our next issue)

DIPHTHERIA ALUM-PRECIPTATED TOXOID

OBSERVATIONS ON IMMUNITY RESPONSE IN THE HUMAN SUBJECT TO VARYING Lf DOSAGE COMBINATIONS

BY

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The investigations were designed to determine the optimum usage of a minimal (or suboptimal) number of Lf units of A.P.T., given as two injections at a monthly interval. The results appear to indicate that when the antigen is thus economically employed there exists a certain essential balance between primary and secondary stimuli. It is believed that information of this description has not yet been produced regarding the behaviour of A.P.T. when injected into the human subject. Principles established in the case of diphtheria A.P.T. may well have a bearing on the optimum usage of antigens associated with other diseases. The following conditions of work and observations are detailed:

1. All precautions in technique were taken as suggested by me previously (Bousfield, 1942).

2. Antigen employed: Squibb A.P.T., Batch 74075, of 27 Lf per c.cm. when prepared in the U.S.A. The Lf value at the time of use was reported by Dr. Percival Hartley to be 21 units, though flocculation was delayed. The latter would not appear to have detracted seriously from the antigenic value, as may be judged from results. During the period of use the A.P.T. was stored under ideal conditions. The antigen was suitable for this type of investigation, being neither too potent nor too weak for adequate dosage variations in convenient fluid measurements. It is useless to employ a high Lf/c.cm. sample for research into the principles of dosage.

3. Population: a suburban area (borough of Heston and Isleworth). The natural Schick-negative rate of children attending the clinics was low—only 6.2% over a period of two years during which the work was performed. Diphtheria incidence had also been very low during the last 12 years, only once having reached the level of slightly over 1 per 1,000 of population in that time.

4. Age groups in the various investigations were kept as constant as possible.

5. The work was performed throughout by one operator.

6. The Schick test was adopted as the criterion of a minimum satisfactory antitoxic response, as blood antitoxin titrations on large numbers of small children are not feasible. The Schick toxin used in all testing was obtained from one source. In the process of retesting the dosage combination employed was not known to the observer until the arm had been inspected. Prejudice in favour of any anticipated result was thereby excluded.

7. All cases described were originally demonstrated to be Schick-positive.

8. Injections of A.P.T. were given by the deep intramuscular route into the deltoid.

9. All post-immunization Schick tests were made from three to five months (nearly always three) after the final injection of A.P.T. This long interval was adopted because many other methods and antigens had been investigated at the same post-Schick interval in the past. Thus results were more informative to me than if the post-immunization tests had been performed after a considerably shorter interval designed to identify subjects at the time of peak antitoxin production. As all groups of children studied were post-tested at about the same average interval, the comparative value of the various results should not suffer by the adoption of the longer interval between injection and testing. Again, from the practical standpoint it is more important to know the conversion rate at a fairly long range rather than at the time of peak antitoxin.

10. The numerical limits of the investigation were determined by the supply of antigen of the same batch number that was available. Other A.P.T. of the same Lf titre might have been employed, but Lf value is not necessarily directly related to immunizing power; thus such procedure could have formed no part of any attempt at a precise series of observations.

11. All doses are described in terms of Lf units as well as fluid measurement. To speak of volumetric dosage alone is most misleading, as in the past much A.P.T. from certain sources proved to be well below the now desired standard of 50 Lf/c.cm.

TABLE I.—Antigen: Squibb A.P.T., Batch 74075 (Strength 21 Lf per c.cm.). Showing Schick Conversion Rate in 1,199 Children. Intramuscular Injections at 28 Days' Interval in Various Dosage Combinations

Group	Lf and Fluid Dosage	Total Lf	No. of Cases	Post-Schick		Conversion Rate (%)	Av. Age of Group (years)	Av. Age of Post-Schick (years)	
				Pos.	Neg.			Neg.	Pos.
1	2.1 + 6.3 Lf 0.1 + 0.3 c.cm.	8.4	169	59	110	65.1	4.6	4.0	5.8
2	6.3 + 2.1 Lf 0.3 + 0.1 c.cm.	8.4	124	19	105	84.7	4.4	4.0	6.5
3	4.2 + 6.3 Lf 0.2 + 0.3 c.cm.	10.5	131	26	105	80.2	4.2	3.8	5.7
4	6.3 + 6.3 Lf 0.3 + 0.3 c.cm.	12.6	137	9	128	93.4	4.3	4.3	5.1
A	2.1 + 8.4 Lf 0.1 + 0.4 c.cm.	10.5	109	18	91	83.5	4.0	3.5	6.3
B	8.4 + 2.1 Lf 0.4 + 0.1 c.cm.	10.5	116	10	106	91.4	4.0	3.7	7.1
5	2.1 + 10.5 Lf 0.1 + 0.5 c.cm.	12.6	95	23	72	75.8	4.7	4.2	6.6
6	10.5 + 2.1 Lf 0.5 + 0.1 c.cm.	12.6	95	20	75	78.9	4.8	4.5	6.0
7	4.2 + 8.4 Lf 0.2 + 0.4 c.cm.	12.6	108	12	96	88.9	4.1	3.8	7.1
8	8.4 + 4.2 Lf 0.4 + 0.2 c.cm.	12.6	115	7	108	93.9	4.4	4.2	7.4

The results of these investigations appear in Table I, and the order here given indicates the progress of the work as a result of accumulating experience. It should be noted that 0.1 and 0.3 c.cm. formed the dosage of this A.P.T. directed