THE AFTERNOON SESSION, JULY 21ST, WAS OPENED WITH A PAPER ON "NEWER ANAESTHETICS: SOME COMPARATIVE CONSIDERATIONS," BY DR. F.H. McMECHAN, WHICH IS IN PART AS FOLLOWS:

There is some confusion about the comparative potency and toxicity of the various gas anaesthetics, partly because most of them, like nitrous oxide, are eliminated intact, and are therefore looked upon as being equally "inert"; and also on account of the fact that some admit of complete and satisfactory anaesthesia in the presence of percentages of oxygen higher than are contained in air; and even further dilutions of the percentage gas mixture with the more insoluble gases.

However, in studying potency and toxicity in relation to minimal and maximal anaesthesia and lethal dosage, the series of gas anaesthetics may be considered as having somewhat the following gradients, with ethylene as unity: nitrous oxide 0.85; ethylene 1; acetylene 1.5; propylene 2.25; butylene 4.5; and amylene 15.

A further clinical concept of these gradients may be had by a comparison of the usual percentage mixtures of these gases and oxygen for the induction and maintenance of anaesthesia. In a schematic way it may be said that each higher member of the series of gases kills readily at the same percentage mixtures at which the previous one maintains safe anaesthesia.

Normally nitrous oxide has the narrowest margin of anaesthesia and the most limited range of percentage mixtures. Not infrequently in pure gas-oxygen administration a leeway of 1 per cent. in the oxygen percentage may definitely determine the control of anaesthesia. Induction may be accomplished either with 100 per cent. nitrous oxide followed by oxygen or by 93 per cent. nitrous oxide and 7 per cent. oxygen; or combination of both methods. During maintenance 10 to 15 per cent. oxygen is rarely exceeded, except in the presence of shock, haemorrhage anaemias, profound sepsis, toxaemia, or cachexia.
Under such conditions the required oxygen percentage may mount to 35, 50, 60, or even higher. Surgical relaxation may be secured by the technique of "secondary saturation" or by the use of synergists. At this point it should be noted that the usual slight duskiness of colour under nitrous oxide-oxygen anaesthesia is no more an indication of cyanosis than the peculiar rosy blush under ethylene-oxygen is an assurance that no anoxæmia is present.

With ethylene it is usually possible to induce anaesthesia with mixtures of 90 to 85 per cent. ethylene and 10 to 15 per cent. oxygen from the beginning. During maintenance the required oxygen percentage may rise to 20 per cent. or more; and better surgical relaxation frequently follows short periods of oxygen up to 40 and 50 per cent. mixtures. Ethylene is thus shown to be slightly cumulative during its administration; although, on account of its low boiling point (—137° F.), it is almost as rapidly eliminated as nitrous oxide. This slightly accumulative effect being due to a higher solubility and some sort of undisclosed and transient physical combination with the lipoids, determines the higher oxygen need, a somewhat wider margin of anaesthesia, and a more intensive obtundent or analgesic effect.

The popularity and widespread use of ethylene has been made possible because ethylene and nitrous oxide are so nearly alike in physical properties that apparatus calibrated for nitrous oxide can be used for ethylene with a margin of error that merely gives a slightly misleading idea of higher percentages than really obtain. Under similar conditions of administration the increased oxygen range with ethylene does not differ very much more than from 3 to 7 per cent. in comparison with nitrous oxide. As with nitrous oxide, the pathological conditions already mentioned demand excessive oxygen percentages. The use of synergists with ethylene for surgical relaxation, especially in abdominal patients who are resistant to nitrous oxide are more susceptible to ethylene and vice versa. Ethylene may readily be used in sequence or combination with nitrous oxide through the same apparatus with proper attachments; many anaesthetists prefer nitrous oxide for the induction
and recovery phases of ethylene anaesthesia (A.D. Luckhardt, W. Easson Brown, T. C. Herb).

Acetylene anaesthesia may be induced in the presence of 20 per cent. oxygen, which may be increased to 30 per cent. in a minute or two. During maintenance the greater solubility and cumulative effect of acetylene usually require an increase of 5 per cent. oxygen and a similar decrease of acetylene in the anaesthetic mixture every five minutes. Thus the closing steps of a long operation may be done under 30 to 40 per cent. acetylene and 70 to 60 per cent. oxygen. Apparatus for acetylene anaesthesia should be especially calibrated for that gas, and the acetone vapour may be eliminated by means of a small filter of activated carbon.

The rapidity with which the oxygen percentage has to be increased during acetylene anaesthesia will depend in great measure on the pathological condition of the patient and the necessity for surgical relaxation. It is being found that, in spite of the apparently greater potency and toxicity of acetylene, it is still sufficiently innocuous that rebreathing during its administration is quite as feasible as with nitrous oxide (H. Wieland, A. and J. D. Goldman).

Propylene is the only other of the newer gas anaesthetics that has been tried out in the operating room. Experimentally it offered some unique possibilities: (a) it was more potent than ethylene or acetylene without being too toxic; (b) it could be used satisfactorily with percentages of oxygen that obviated anoxæmia and maintained the alkaline reserve; and (c) more than this, a third gas (nitrogen) could be used at the same time to render the anaesthetic mixture non-explosive to static and perhaps to other sources of ignition as well.
Dr. E. I. McKesson's paper "Guiding Signs and Dangers" was in part as follows:—

Ethylene-oxygen in about half of the cases produces a slower pulse by about ten beats to the minute than nitrous oxide-oxygen. Sometimes the slowing amounts to a bradycardia. Those cases with a slow pulse seem to do best under its influence. In other cases the pulse rate increases over that of nitrous oxide-oxygen, and these often show a marked fall in blood pressures, resembling shock. In the bradycardia cases the blood pressures may fall somewhat, but not out of proportion unless the blood is being overdosed, which may be quickly determined by a few breaths of oxygen of higher percentage.

The blood pressures under nitrous oxide-oxygen are variable with the depth of anaesthesia, trauma, blood loss, etc., but under normal conditions tend to remain within normal limits. The usual result of ethylene-oxygen is a fall in blood pressure similar to ether after the stage of induction. Time will not permit a full discussion of pulse-blood pressure ratios.

The eye signs, particularly the pupil, are more sluggish and unreliable under ethylene than with nitrous oxide-oxygen. However, deep narcosis usually causes a dilatation of the iris. But when it occurs it is not as promptly remedied by the administration of oxygen as it is after nitrous oxide-oxygen. There is less oscillation of the globes with ethylene.

When high concentrations of ethylene are necessary to secure relaxation, anoxæmia frequently prevents it, and in these cases recourse may be had to nitrous oxide or other procedures, such as premedication or ether. My use of ether for this purpose is rare indeed. In 1925 ether was not used in a single case. This year it has been used in five or six cases for various reasons.

Ethylene, like nitrous oxide, co-ordinates well with morphine-hyoscine premedication. Occasionally atropine is administered during the narcosis for bradycardia, but never as a routine. We use from 1/6 to 1/3 grain of
morphine, usually 1/4 grain in adults, and never more than 1/100 grain of hyoscine.

Cyanosis of some degree is not infrequent in the use of nitrous oxide-oxygen. This is most marked in the early minutes of narcosis while saturation is in progress. Later in the narcosis, cyanosis is usually absent or of slight degree. Cyanosis is not a sign of anaesthesia, hence it cannot be relied upon. In ethylene-oxygen anaesthesia cyanosis is not as frequently seen, nor is it the pure cyanosis of anoxæmia seen in nitrous oxide anaesthesia, but an ashy hue associated with a more precarious state of the patient when it occurs.

Blanching or paleness with ethylene is usually due to nausea. Whether the colour of the blood and skin in ethylene anaesthesia is lighter, due to some action upon the hemoglobin or to a greater decrease in general metabolism or to some impurity or contamination of the gas such as carbon monoxide, is not yet established. But it may be due to all three or any one of the three in a given case. For myself, I prefer to use ethylene, not as a routine, but on indication for some desired pharmacological action, the same as one would employ morphine, hyoscine, atropine, digitalis, ether, etc., relying upon nitrous oxide-oxygen as the basic anaesthetic.

It appears from the signs that ethylene is more depressing and powerful generally than nitrous oxide.
There are four outstanding functions for an anaesthetizing apparatus. The first of these comprises suitable inhalers, connexions, valves, etc., for the exclusion of air. The second embodies positive control of the mixture of the gases to be administered. The third is represented in the control of the pressure of mixed gases in the inhaler. The fourth is the regulation of breathing. A fifth might be added as an accessory of great clinical importance—namely, a mechanism for artificial respiration by inflating the lungs with oxygen.

Mixing two gases in proportions sufficiently accurate to maintain narcosis has been a very difficult procedure to carry out over a long period. There are several reasons. First, gases are composed of rapidly moving molecules with a vacuum between them, resulting in a most mobile body. Secondly, owing to this great mobility, and also to the exceedingly rapid absorption of these molecules by the blood, the effect of any change in the proportions of these two kinds of molecules is quickly reflected in the narcosis.

The Intermittent Flow Method.

Twenty years ago it was thought by some anaesthetists that the best way to obtain and maintain the mixture for clinical work was to flow the two gases together continuously and uniformly, varying the proportions usually by adjusting the flow rate of the oxygen. This, however, failed at once, since the nitrous oxide tank valve could not be made to deliver this gas uniformly because of a progressive fall of pressure in the tank as it was used. Likewise the oxygen varied, although in practice it did not freeze. To overcome this difficulty, a few years later a pressure-reducing valve or regulator was interposed between the tank and mixing apparatus proper, so that the falling pressure in the tanks might not so greatly influence the delivery rate. This marked some advance in the evolution of the anaesthetic, but was not completely successful because, however carefully the
The regulator had been constructed, it was still subject to relatively large variations of pressure and delivery rate when applied to gases for this purpose. Moreover, the very small apertures through which the gases were delivered often became more or less obstructed by small particles of water, ice, or foreign matter, or by changes in temperature, and the mixtures varied accordingly between limits quite incompatible with smooth narcosis.

The Intermittent Flow Method.

After considerable clinical experience with various forms of mixing apparatus then available, I experimented along another line. The mechanical problem presented many difficulties, but it appeared that if the nitrous oxide and the oxygen bags could be kept equally filled or under equal but very low pressure by some automatic bag-filling mechanism, progress might be made. After several trials, such valves were perfected which automatically replenished the oxygen and the nitrous oxide bags at each breath—stopping the flow from the tanks into the bags while the patient exhaled and paused between breaths. The bags were thus kept equally filled with their respective gases, regardless of the rate or volume of respirations.

Instead of continuous flow apparatus this became an intermittent flow device. Certain advantages, however, resulted, among which were a foundation for proper mixture control and relief from attempts at manually adjusting the rate of flow, since the respirations regulated this function much better than the anaesthetist had done before. The possible range of automatic gas delivery was enormous—from nothing to more than 33 gallons a minute, so that no patient could exhaust the supply, however rapidly he breathed. The intermittent flow principle also adapted itself to the technique for intermittent administration in producing analgesia for obstetrics.

With the two gases in separate bags but kept at equal pressures the first factor in producing the desired mixture was then satisfied and the construction of a suitable mixing valve mechanism was undertaken.
Professor Finsterer, Vienna, read his paper, "Anaesthesia in Abdominal Operations", the following being an excerpt.

In greater abdominal operations the method of anaesthesia may decide the end result, as injuries from narcosis to the diseased organs lead to death after 3—5 days. To avoid such fatalities the amount of narcotic must be reduced by injection of morphine with atropine, by sparing with ether (experienced anaesthetists), by using nitrous oxide or narylen instead of ether.

The greatest amount of narcotic can be spared by blocking the nerves leading to the operative field through novocain; therefore in every greater operation (stomach or intestinal resection) an exact local anaesthesia of the abdominal wall and injection of novocain into the mesenteries, should be performed even in cases of general narcosis, resulting in a combined anaesthesia.

Different methods of regional (local) anaesthesia may be used in laparotomies. But in every method, a very exact anaesthesia of the anterior abdominal wall is the most important point. The amount and concentration of the agent should be in proportion to the vitality of the patient. As a rule 200—250 cc. of one half per cent of novocain or 1/5 per cent tutocain solution are sufficient; in anaemic or very cachectic patients only a 1/4 per cent novocain solution should be used.

Paravertebral anaesthesia is advantageous only in cases where the injection of one side suffices (cholecystectomy, colon resection).

Splanchnic anaesthesia is a very effective method in stomach resection, gall bladder operations; when carefully performed (no intraspinal nor intravenous injection!) it is nearly harmless. Kappis himself performed over 1,000 anaesthesias without fataliy. Braun made 875 splanchnic anaesthesias after his own method, and after the same method Payr 210, Haberer 209, Linhard 181, Kirchmayr 91, and myself 807, all cases without death. To avoid bad by-effect the amount and concentration of novocain should be in proportion to the patient's vitality. In patients with severe anaemia or progressed cachexia only 50 cc. of 1/4 per cent. novocain solution should be used for splanchnic anaesthesia, or if
there is no contra-indication against ether, mesenterial anesthesia, if necessary combined with a little ether, is preferable because less dangerous.

My own experience with Braun's method is based on: (a) 112 stomach resections for cancer (supported by ether 5 times), (b) 468 resections for gastric or duodenal ulcers (33), (c) 63 radical operations for gastro-jejunal ulcers or gastric ulcers not healed by gastroenterostomy (25), (d) 89 cholecystectomies and choledochotomies (8), (e) 75 of explorative laparotomies, gastroenterostomy etc. (no ether). Ether was used with nervous patients in the beginning of the operation to perform the local and splanchnic anaesthesia, in cases of gastro-jejunal ulcer to separate the adhesions before the splanchnic anaesthesia or at the end of this long lasting operation when splanchnic anaesthesia has gone before finishing the mobilisation.

Meeker's view that splanchnic anaesthesia is only dangerous and not effective, therefore superflous, is contradicted by the experiences in over 2,300 cases of splanchnic anaesthesia after Braun and 1,000 cases performed by Kappis himself.

Parasacral anaesthesia is useful for every operation on the rectum, bladder and uterus, but it must be combined with injection of novocain on the 5th lumbar vertebra to block the lumbar ganglion. Through this method the results of abdomino-sacral resection of the cancer of the rectum can be improved, (my own mortality, formerly 31 per cent, now 10 per cent.)

Spinal anaesthesia is useful only in pelvic operation. I prefer parasacral anaesthesia which is less dangerous. High spinal anaesthesia is too dangerous, especially for operation in the upper abdomen, and should therefore not be used.

The greatest advantage of regional anaesthesia alone or combined with a little ether, is the fact that contra-indications (severe lung and heart diseases, old age, progressed cachexia etc.) need no longer be considered, despite which, the total result can be improved, as fatalities by so called "operative shock," gastric or intestinal atony or lung complications, are almost always prevented. In my own material among 841 stomach resections for ulcer, 185 intestinal resections and
259 cholecystectomies, I have not had a single fatality from "operative shock", atony or pneumonia, despite the fact that 137 patients were from 60-88 years of age.

The gastric resection for ulcer which I perform almost in all cases shows a mortality of 5.3 per cent. in 841 cases. In cases with acute haemorrhage the mortality was high (54 resections with 8 fatalities, 14.8 percent.), especially in late operations (28 resections with 7 fatalities, 25 per cent.). During the war the mortality in the other cases was high (peritonitis), 13.5 per cent. ; since 1919 it has gone back to 2.7 per cent.. There was no fatality from pneumonia among 841 resections, although 87 patients were from 60-78 years old.

In stomach resections for cancer the mortality depends on the extent of a resection, being higher in cases in which parts of the invaded organs (liver, pancreas, colon etc.) had to be resected; among 109 such cases 44 fatalities occurred, 41.7 per cent. whereas in 155 resections of the stomach alone, there were 11 fatalities, 7.1 per cent. As in cases of progressed cachexia also, the resection can be successfully performed (in 13 cases the weight of the patient was less than 80 pounds, all cases recovered after resection). In using local anaesthesia the 2 stage resection is no longer necessary.

24 hours after resection of 4 meters of gangrenous strangulation in cholecystectomies and choledochotomies the results are improved as fatalities on the 3-5th day through liver insufficiency and death from pneumonia have not occurred. In 216 cholecystectomies there were 5 fatalities (2 lung embolia, 2 peritonitis, 1 post operative haemorrhage). In 43 cases of cholecystectomies and choledochotomies for common duct obstruction, there were 4 fatalities in very progressed cases (2 peritonitis, 1 subphrenic abscess after 4 weeks, haemorrhagic diathesis). Among 20 patients over 60-77 years, only one died, 4 weeks after the operation, from subphrenic abscess.

In the resection of the small intestine the results depend firstly upon the duration of the obstruction and the presence of peritonitis. In 56 resections I had 8 fatalities, 5 due to gangrene and peritonitis, 1 due to thrombosis of the vena meseraica and vena portæ, a 76 year old woman died
lated bowel; it is remarkable that of 9 patients between 71 and 87 years, only the woman with the extended gangrene died.

In colon resection the insufficiency of the sutures can be prevented as the surgeon has plenty of time to make a very broad lateral anastomosis with 3 layers of sutures, and post-operative atony, which endangers the sutures, is not observed. By this way the colon resection for cancer shows good results with lateral anastomosis, if the bowel is evacuated normally, or through a preliminary colostomy on the transverse colon. Of 19 resections for cancer of the left part of the colon, with lateral anastomosis, 2 patients died (1 case peritonitis, no leakage, the other, heart insufficiency, after 2 weeks). No operative shock, no pneumonia, despite the fact that 11 were over 60 years.

Conclusion.

In major abdominal operations general narcosis with ether or chloroform injures the parenchymatous organs on account of its longer duration. This may lead to death through insufficiency of the organ.

These injuries of the organs may be avoided by the use of combined anæsthesia; therefore it should be employed in every greater laparotomy in which it is impossible to perform the whole operation under regional anaesthesia. In combined anæsthesia Nitrous-oxide or Narycyn are the least injurious.

Mesenteric anæsthesia is almost harmless and may be resorted to in every case. It is the most effective agent in the combined anæsthesia.

Paravertebral anæsthesia should be used in operations in which the injection on the one side only suffices.

Splanchnic anæsthesia after the method of Braun is almost without danger, and in about 90 per cent of operations on the upper abdomen sufficient.

Parasaenal anæsthesia combined with blocking of the lumbar segment is sufficient for radical operation for cancer of the rectum and for all gynecological operations.

By the use of regional anæsthesia the results of great abdominal operations are improved because death from so called operative shock, pneumonia and atony of the bowel can be almost always avoided.
C. Langton Hewer, M.B., B.S. Lond., read a paper entitled "Endotracheal Nitrous Oxide-Oxygen-Ether Anaesthesia in Gastric Surgery. The following is an excerpt:

We come to the method which in my opinion gives the best results of all in gastric surgery; this consists in administering a mixture of nitrous oxide, oxygen, and ether through a tracheal catheter. I have now employed this method as a routine for five years in about 3,500 cases, of which about 1,000 were for upper abdominal operations.

The apparatus required is not extensive. Any sight-feed gas and oxygen machine can be employed, although it is better to have either a pressure gauge or mercury manometer connected with the exit tube to give an indication of the endotracheal pressure. If all the connections are rigid, an adjustable safety-valve is also advisable, but in most types of apparatus the corks will blow out of the bottles long before a dangerous pressure is reached.

The technique is as follows. The patient is given a preliminary atropine injection and is fully anaesthetized by any method which the administrator prefers. When the jaw muscles are completely relaxed a direct-vision laryngoscope is passed along the dorsum of the tongue until the epiglottis is seen. This is gently pushed forwards with the curved end of the laryngoscope, and the glottis will then come into view. The end of a tracheal catheter is then smeared with sterile vaseline and slipped between the vocal cords and pushed onwards for another three or four inches. The laryngoscope is then withdrawn, and the proximal end of the catheter connected up to the exit tube of the gas and oxygen machine. Difficulties in passing the catheter are nearly always due to the patient being insufficiently anaesthetized. In this case it may be almost impossible to see the glottis, and even if this is accomplished the cords will probably be in a state of adductor spasm. If a catheter is then forced between them some post-operative laryngitis will almost certainly ensue. Opinions differ as to the best position for the patient's head. I have found that if it be placed just flat and exactly in the middle line little difficulty is usually experienced in
finding the glottis. Hyperextension of the head, on the other hand, although favoured by laryngologists, stretches the soft parts and should be avoided. When the catheter is in position, a mixture of 50 per cent. nitrous oxide and 50 per cent. oxygen passing through ether is first employed. This may cause a certain amount of coughing, which soon passes off as the anaesthesia becomes more profound. The amount and proportion of the gases are then regulated until the colour of the mucous membranes is just pink and the manometer shows a pressure of about +5 mm. Hg on inspiration. In an average case the breathing becomes shallow and regular as in a sleeping patient, but occasionally there is a certain amount of obstruction to the return airway due to a large tongue, in which case an artificial airway should be inserted. Two catheters are, as a rule quite unnecessary in gastric case. By increasing the proportion and pressure of oxygen the respiratory movements can be brought down to practically zero, and, indeed, complete apnoea may occur for a considerable time, the oxygen diffusing through the bronchioles and alveoli sufficiently rapidly to oxygenate the blood. This, of course, is of great assistance to the surgeon when performing anastomoses, as the suture line is perfectly still.

In long gastric operations it is always advisable to take blood pressure and pulse records at least every five minutes. This can easily be done by strapping a stethoscope end over the brachial artery in the antecubital fossa just below the cuff of the sphygmomanometer. Systolic and diastolic pressures should both be taken, and, if possible, recorded as a graph. In my opinion the best indication of the patient's general condition is given by observing the tendency of the pulse pressure and pulse rate. By this means ample time is given for antishock methods to be adopted before severe collapse has occurred.

Post-operative pulmonary complications can be minimized in two ways. First, at the end of the anaesthesia the gas-oxygen-ether mixture should be switched off and a mixture of 90 per cent. oxygen and 10 per cent. carbon dioxide from a separate cylinder substituted. This will cause immediate forced breathing by the stimulation of the respiratory centre.
by the carbon dioxide. The ether vapour will consequently
be rapidly rushed out of the lungs, the blood will be fully
oxygenated by the 90 per cent. oxygen, and the bases of
the lungs will be expanded by the hyperpnoea. Patients
can be brought round very rapidly by this de-etherizing
process, but in gastric cases it is better to discontinue it
after about five minutes. The patient will then relapse into
a state of light anaesthesia and will remain free from pain
for a considerable time. The second way to avoid respira-
tory complications is to give small doses of atropine
repeatedly for three days after operation—gr. 1/200 hypo-
dermically three times a day is a useful average dose. The
only possible objection to this treatment is the antispasmodic
action of the drug, which might possibly predispose to
paresis of the bowel, but I have never seen any trouble
follow from this cause.