PROBLEMS IN SUPPLY OF ANESTHETIC GASES IN THE
EUROPEAN THEATER OF OPERATIONS,
U. S. ARMY *

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It was with some hesitation and diffidence that I accepted an invitation
to present a paper before this gathering, which is representative of the
Compressed Gas Industry. I do not claim to be a business man interested
in the supply of gases except as a doctor is interested in the supply
and identification of the medicinal agents that he uses. I was thrust into a position which, for me, was unique when I was recruited
and sent overseas to become Senior Consultant in Anesthesiology to
the Chief Surgeon of the European Theater of Operations, U. S. Army.
I thought that you would be interested in hearing of the difficulties which anesthetists encountered in that effort which, as you know, was a major
one of tremendous proportions. It is my intention to outline to you in
chronologic order situations in reference to supply of anesthetic gases
which were encountered. In order to facilitate that outline, it is best
to describe certain factors in organization.

Immediately upon arrival of the Senior Consultant in Anesthesiology in England, in September 1942, at the Headquarters of the Service
of Supply, he became a member of the Professional Service Division
in the Office of the Chief Surgeon and, in that capacity, he represented
anesthetists. His associates were specialists, each representing his
particular specialty. The Division was directed by Colonel James C.
Kimbrough, M.C., and it was divided into two Sections; one surgical
under the leadership of Colonel Elliott C. Cutler, M.C.; and the other
medical under the guidance of Colonel William S. Middleton, M.C. Because anesthetists render their service to patients at the same time as
surgeons, anesthesiology was considered as a subdivision of the Surgical
Section but because anesthesiology involves so many considerations
that are medical in scope, liaison with the Medical Section was close.
The function of personnel of the Division was to observe, report and
recommend, through the Director, to the Chief Surgeon. Observation
included all phases of unit organization, supply of equipment and therapeu
tic agents, as well as an evaluation of personnel in reference to prac-

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tice. In the early stages of planning for invasion of northwestern Europe, Tables of Supply were studied for each type of unit in relation to the task that it was designed to fulfill. Items of equipment and supply were deleted, others were added, to meet the needs of current practice.

In order to carry out these duties intelligently, it was considered that the first requisite was to become familiar with provisions for anesthesiology in the British and Canadian Armies. Following renewal of acquaintance with Air Commodore R. Macintosh, Senior Advisor in Anesthesiology to the Royal Air Force, and with Colonel Beverly Leach, C. O. 5th Canadian General Hospital, arrangements were made to meet Lieutenant Colonel Ashly Daly, Senior Advisor in Anesthesiology to the British Army. These men offered the fullest cooperation in making arrangements for me to visit and interview anesthetists in British and Canadian hospitals. Inspection of several British hospitals, both military and in the Emergency Medical Service (civilian), revealed that they were equipped to carry on all phases of anesthesia such as would be conducted in their normal civilian hospitals, with the exception that in military hospitals provision was not made for the use of cyclopropane and carbon dioxide absorption. Anesthetic machines were procured from several British companies. Expendable items and parts were not completely standardized and, therefore, were not completely interchangeable. Inspection of Canadian hospitals revealed that equipment of American origin equaled that in civilian hospitals in the United States or Canada. Anesthetic machines were standardized, all being of the same model, providing for the use of carbon dioxide absorption and cyclopropane. Anesthetic gases were supplied in cylinders of Canadian origin in design and manufacture.

It was found that American military hospitals, in late 1942, were equipped partially with anesthetic machines of British origin requiring the employment of cylinders of British design and manufacture. Refilling of cylinders was accomplished through British trade channels. New hospitals arriving from the United States brought anesthetic machines of American manufacture, produced by two well-known companies. Expendable items and parts were not interchangeable in the relation of one American machine to the other, nor in relation to the British machines already possessed in other hospitals. Because expendable parts were not interchangeable, four pools of maintenance items were established by the Supply Division in order to fill requisitions for parts for anesthetic machines built by two British Companies, the British Oxygen Company and the Medical and Industrial Equipment Company, and by two American Companies, the Heidbrink Company and McKesson Technical Appliance Company. Descriptions in American Tables of Supply were inadequate to eliminate the possibility of obtaining parts built by one manufacturer when requisitions were submitted for parts for machines built by the other American manufacturer. These difficulties were further enhanced by discrepant-
cies in description and grouping of parts in British and American Supply Tables. Supply officers found it difficult to catalogue and store parts, and issue was complicated because newly arriving anesthetists were unfamiliar with terminology to be employed in making requisitions. These conditions in supply influenced practice and during an emergency in an operating room, unless the anesthetist was ingenious and had thoroughly prepared for it, the outcome of a critical operation was put in jeopardy. When a sudden need for accessory equipment arose, nurses and corpsmen were likely to respond to it by bringing parts that would not fit.

Cylinder yokes of American machines were of typically American design and were not of the design usually supplied by American manufacturers for export to Great Britain which would accommodate either American cylinders or British cylinders number seven. Lack of standardization made it necessary for the U. S. Army to procure and distribute cylinders of both British and American origin. Shipping space was at a premium and because of this, it was necessary to equip American gas machines with British cylinders. This could be done only after the procurement of suitable adapters for reducing regulators for oxygen and for nitrous oxide, in the case of all cylinders of over 450 gallons capacity. Yoke adapters were procured for American cylinders, designated sizes C and D. The medical section of the British Oxygen Company, under the direction of Mr. H. A. Chapman, was very helpful in evolving designs of these adapters and in the production of models. Requisitions for some thousands of the several adapters were processed through to American Headquarters to the British Ministry of Supply. Procurement through British channels necessitated allocation of scarce metals, manufacturing facilities, and labor to produce them. All this was time-consuming and delivery was slow in spite of the fact that duplicating requisitions were placed in the United States. British suppliers were forced to equip their filling stations with adapters to accommodate American cylinders and to orient their workmen in recognition of American cylinders and identification of the gas required for each type. It was necessary to take precautions that American cylinders filled through British trade channels were delivered only to American hospitals possessing American anesthetic equipment, while British cylinders were delivered to hospitals possessing only British equipment. As can be easily realized, such diversion in channels of supply is difficult and particularly so in a Theater of Operations suffering from “growing-pains.”

These major difficulties of supply were enhanced by the practice in the United States of shipping a gas machine in one crate and equipment of deteriorating quality (rubber parts) in another. This practice was predicated on the assumption that, if deteriorating parts were kept in storage with nonexpendable equipment for an appreciable length of time, upon the arrival of such equipment in a Theater of Operations,
they would no longer be usable. The plan had been to "marry" units of expendable equipment with each unit of nonexpendable equipment, at the Port of Embarkation. When this "marriage" failed to take place, machines arriving without their deteriorating parts were useless until deteriorating parts of British design and manufacture could be obtained. This situation was particularly difficult in relation to American machines that were shipped with hospital units intended for use in the North African Theater. As you will recall, the North African Campaign opened on November 8, 1942. Hospital units staged for a very short period in Great Britain, during which time there was no opportunity for anesthetists to check their equipment for completeness before re-embarking for Africa, where procurement of deteriorating parts was impossible because of lack of an established industry as in England where substitute expendable items could be obtained. It was necessary to await arrival of expendable items from the United States. During the early stages of the ship-to-shore operation and thereafter, in many instances, choice of anesthesia was limited to pentothal sodium administered intravenously and to ether administered by the open drop method. Intermittent positive pressure was not available for penetrating wounds of the chest. Fortunately, this situation was corrected at the source and American manufacturers were instructed to deliver each gas machine complete in a single crate.

Early in December 1942, recommendations were submitted through channels to the Surgeon General that: (1) a competent consultant in anesthesiology be obtained to function in Washington in cooperation with Personnel and Supply Divisions; (2) Tables of Supply be amplified to meet modern requirements; (3) standardization of suitable equipment for each type of unit (example: Surgical, Evacuation, Station and General Hospitals) be achieved, permitting interchangeability of rubber parts, endotracheal equipment, and masks; (4) the work of the Committee on Standardization, initiated through the efforts of the American Society of Anesthetists, Inc., be supported and with the cooperation of the Army and Navy, its functions be pushed to their logical conclusions; and (5) this effort, directed toward uniformity of threadings, tapers, outlets, and valves, be coordinated with projects in the Air Force for standardization of methods of supply, storage, and administration of oxygen to air crews.

In 1943, problems in equipment and supply inherent in their design were met by palliative measures. An article entitled, "Consolidated Report Regarding Equipment for Anesthesia and Oxygen Therapy in E.T.O. (Northern Ireland Base Section excepted)," was prepared for submission 31 January 1943. The salient points in the report covered the requirements for gas machines and provision of adapters to permit use of supplies of gases from British sources. It recommended that each hospital be provided with sufficient quick coupling oxygen sets (source, British Oxygen Company) for distribution of oxygen in hos-
pitals to cover the contingency of gas attack. It was pointed out that the use of oxygen tents was impractical in the Theater because of lack of freely available ice and because of difficulties of nursing in cases of multiple wounds. The acceptance by the Senior Consultant in Anesthesiology of responsibility for equipment for oxygen therapy brought to light new difficulties in standardization. Reducing regulators on anesthetic equipment were designed for the use of so-called medical cylinders containing oxygen, the outlets of which had an outside diameter of 0.825 inch. American regulators for oxygen therapy were produced by some American manufacturers designed to utilize commercial cylinders containing oxygen, the outlets of which were 0.903 inch in outside diameter. Other American manufacturers supplied regulators for oxygen therapy designed to fit medical oxygen cylinders. The presence in the theater of two types of American equipment necessitated duplication of means for adaption of British cylinders to each type and also necessitated the procurement of adapters which would permit the utilization of American medical or American commercial cylinders to either American medical or American commercial reducing regulators. The original estimate of the number of adapters required was predicated on the basis that the major supply of anesthetic machines and apparatus for oxygen therapy would be procured from British sources and would, therefore, not need adaption to British cylinders. At the time (31 January 1943), the outcome of the U-boat campaign looked grim but, with the marked Allied successes in dealing with submarines, delivery of equipment from the United States increased beyond original hopes. American machines to which American anesthetists were accustomed arrived in greater numbers than had originally been expected but the procurement of adapters permitting use of British cylinders on them lagged behind needs thus created. It was noted that newly arriving American anesthetists familiar only with American equipment and supplies were at a loss to recognize the uses of adapters that were supplied them in preparation for employment of British cylinders. While they continued to employ American cylinders that had been a part of their unit equipment, adapters that were subsequently needed tended to be misplaced or lost. It was necessary to issue circular letters describing eccentricity in design between American equipment and British supplies, with explanations including diagrams of the use for which the adapters were intended.

In view of this confusion, it is little wonder that an accidental death occurred when an anesthetist, having worked in an American hospital equipped with American supplies, was eventually moved to an American hospital supplied with both British and American cylinders. When an American cylinder was emptied, it was replaced by a British cylinder through the use of one of the adapters supplied. Both cylinders were painted green and, because of lack of easily recognizable means for further identification, he thought that he was dealing with a cylin-
der containing oxygen. Green British cylinders contained carbon dioxide and the patient died because of its administration. This occurrence brought to the fore the problems of identification by color schemes which were national rather than international in scope. As a matter of fact, no national scheme for color identification was fully accepted in the United States. The U. S. Navy had long been using one scheme, whereas civilian hospitals in the United States were supplied with cylinders, approximately 4½ inches in diameter by 26 inches long and smaller, identified by color markings established in Simplified Practice Recommendation R-176-41 approved 29 January 1941. So far as the European Theater of Operations was concerned, identification, in the main, followed this Simplified Practice Recommendation. Unfortunately, in many instances, this scheme of color identification conflicted with the British scheme and grave sources for error were existent both in relation to workmen identifying and refilling cylinders and to anesthetists employing the contents therefrom.

In 1944, a command decision was reached that all American cylinders employed in Great Britain would be repainted according to the British standard color scheme. This entailed a great deal of work, the accomplishment of which in the Medical Department required designation of teams of anesthetists to inspect American depots, identify cylinders as to their contents and supervise their repainting and marking by means of stencils. Between thirteen to fifteen thousand cylinders were thus processed. The effort had been precipitated by delivery to a United States depot of over one hundred cylinders incorrectly filled with carbon dioxide instead of oxygen. Fortunately, only six cylinders had been issued before the error was detected. Upon the recommendation of the Senior Consultant in Anesthesiology, all issuing depots were closed except to meet specific emergencies until the six cylinders were found. They were traced by means of the records, located and emptied without any patient having suffered because no gas had been administered from these cylinders. The project of repainting and stenciling cylinders was undertaken reluctantly because it contravened the principle that only the supplier of gases should identify them and, thereafter, identification should not be altered or added to. The need for adhering to this principle was demonstrated when it was subsequently found by the British Oxygen Company that two cylinders had been marked in error. These cylinders having been so marked when empty, the error in identification was noted when they were to be refilled and so again, no injury to patients resulted. Because of these circumstances, basic contracts negotiated through the British Ministry of Supply were altered and suppliers were made fully responsible for complete identification of gases in cylinders and maintenance of these means of identification including painting and stenciling. This represented a distinct step forward. Difficulties in identification of gases in American cylinders were reported to the Office of the Surgeon General
and subsequently a report was received that the Port of Embarkation had been made responsible for the stenciling of all cylinders to be sent to the European Theater. With the receipt of this report, it was felt that another real step forward had been taken in eliminating hazards of identification. As will be explained, elation over this progressive step was short lived.

In July 1944, an administrative memorandum was issued by the Office of the Chief Surgeon which contained five sections covering the procurement of medical gases, adapters, employment of carbon dioxide mixtures, cyclopropane, and identification of medicinal gases. Although the attachment of cylinders containing pure carbon dioxide to apparatus designed for inhalation therapy or for production of anesthesia had previously been prohibited, this new memorandum publicized the fact that no longer would mixtures of carbon dioxide be available for issue. Elimination of these mixtures was considered the lesser of two evils where difficulty in identification was weighed against questionable clinical advantages accruing from use of the mixtures.

In planning for D. Day, it was established as a general principle that only American-made cylinders would be used in continental operations and British-made cylinders would be used in fixed medical installations in the United Kingdom. Accumulation of American-made cylinders in U. S. Medical Depots was gradually achieved. This was accomplished when empty American-made cylinders were sent in for refill. British-made cylinders were returned to American Hospitals to replace the American-made cylinders that were being segregated for ultimate shipment to France.

The problem of identification of cylinders arose once again after the capture of Paris, France, when the possibility of having French commercial producers refill American cylinders was considered. It was recommended that basic contracts with the French include the stipulation that all cylinders be stenciled in English with the name of the gas contained.

To the dismay of those vitally concerned in the European Theater, late in 1944, cylinders painted lusterless olive drab were received from the United States. It was subsequently learned that in September, a technical bulletin had been issued by the Corps of Engineers in Washington instructing that all cylinders in the future would be painted olive drab, irrespective of the gases contained. It was unfortunate that these cylinders did not possess permanent imprints indicating the name of the gas contained but were only stenciled. These stencils were subject to erasure during transportation and in open storage. Such cylinders continued to be received throughout the remainder of the campaign.

Difficulty resulting from the design of cylinders and lack of standardized means of identification of gases contained was not limited to the European Theater of Operations. It was common to all theaters in
matters of principle, differing only in its aspects according to nations and services involved. These difficulties were in part recognized by the combined Production and Resources Board and, as a result, in 1943 a conference was held in the United States followed by another conference in London in August and September 1944. A third conference was held in Ottawa, Canada, in September 1945, including representatives from the United Kingdom, Canada and the United States. The London conference was for the purpose of receiving information of British and American standards in order that adapters might be designed and produced. Difficulties arose in the production of adapters owing to multiple standards in the United States and the third conference was to coordinate latest information on acceptable American standards. Emphasis was placed on acceptance of standards that provided for noninterchangeability of gas connections, thus safeguarding against linkages that might be made in error. The report of the Compressed Gas Manufacturers Association entitled, "American Compressed Gas Cylinder Valve Outlets," lists three gases, carbon dioxide, nitrous oxide, and oxygen, as being distributed in large cylinders having the same valve outlet. It is highly desirable that this alternate medical standard for oxygen be eliminated completely. Specifications for procurement of valves for the U. S. Army no longer include the medical standards (OD.825). It is hoped that this alternate standard will be eliminated from civilian channels of distribution too. Further remedy can be achieved by discontinuance of the use of carbon dioxide and carbon dioxide and oxygen mixtures for inhalation, leaving only nitrous oxide to be distributed through medical standard valves. The report listed six valves for small cylinders containing medicinal gases, including oxygen, which are equipped with flush outlets. In the case of all these gases, cylinders can be linked in error and no safeguard is provided. It is highly desirable that a project for development of design and establishment of noninterchangeable standards be undertaken. The cooperation of the Compressed Gas Manufacturers Association is solicited. Because the Medical Section of the British Industry is voluntarily undertaking to redesign valves and valve connections for medical gases at this time, if international standardization is to be achieved, the project of establishing noninterchangeability in linkages should be undertaken on an international cooperative basis. In view of the difficulties that were occasioned in the European Theater, including wastage of scarce metal and personnel to fashion adapters, it is sincerely hoped that this will be done in such a manner that alteration of the existing American equipment may be effected as a field fix. In this regard, Dr. Joseph Kreiselman, Civilian Consultant to the Office of the Surgeon General, U. S. Army, following the ideas of Dr. J. A. Heidbrink, has recently developed apparatus for a field fix which will provide noninterchangeability of flush outlets for yokes. It is worthy of serious consideration.
It is with great satisfaction that I can report adoption by the U. S. Army, Navy, and Air Force of a color code for identification of compressed gases in cylinders. It is worthy of acceptance by the Compressed Gas Manufacturers Association and other federal services such as the Bureau of Standards and by the American Standards Association.

In conclusion, difficulties encountered in distribution of compressed gases in the European Theater of Operations, U. S. Army, have been outlined in so far as they affected the practice of anesthesiology. It is obvious that remedial measures of a fundamental nature should be undertaken if lives of the sick and wounded are to be saved.

MEETING OF THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS, INC.

REGIONAL MEETING IN CONJUNCTION WITH THE

CHICAGO SOCIETY OF ANESTHESIOLOGISTS

Chicago, Ill., May 29 and May 30, 1947

   Illinois Research Hospital—Dr. W. H. Cassels and associates.
   Wesley Memorial Hospital—Dr. Mary Karp and associates.
   St. Luke's Hospital—Dr. W. A. Conroy and associates.
   Michael Reese Hospital—Dr. B. Stodsky and associates.
   University of Chicago Clinics—Dr. H. Livingstone and associates.
   Evanston Hospital—Dr. E. Remlinger and associates.

II. Conferences. Friday, May 30 (Memorial Day). Congress Hotel. Afternoon, commencing at 1:30 P.M. E. B. Tuohy, M.D., President A.S.A., presiding.
   1. Methods of Testing Analgesics—Carl Pfeiffer, M.D., Chicago, Ill.
   2. Intracranial Vasococstrictors—Mary Karp, M.D., Chicago, Ill.
   4. Chloroform, Old—Donald Kindachi, M.D., Madison, Wis.
      Chloroform, New—Lucien Morris, M.D., Madison, Wis.

III. Dinner—Round Tables with Moderators—Congress Hotel, 6:00 P.M.

IV. Evening Meeting—Congress Hotel, 8:30 P.M., W. A. Conroy, M.D., President C.S.A., presiding.
   Symposium on Nitrous Oxide.
   2. Oxygen Requirements—W. O. McQuisten, M.D., Peoria, Ill.