

MOBILE ROENTGEN RAY APPARATUS*

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THE necessity for the employment of mobile roentgen ray apparatus in time of war has been recognized from the earliest days of the roentgen ray. Small transportable outfits were probably first used on an extensive scale during the Boer War. At that early time the outfits were necessarily very limited in their output, since even stationary apparatus was not highly developed. In all important wars since that time roentgen ray work has been done with mobile apparatus supplying its own current. The most usual type has been a coil and interrupter actuated by current from storage batteries, or from a dynamo run by a gas engine. Sometimes a small gas electric set was carried to recharge the storage batteries, and sometimes a dynamo was operated directly from the motor of the automobile in which the outfit was transported.

The World War was of such magnitude, both in respect to the total number of casualties and to the number occurring over short spaces of time in individual engagements, as greatly to increase the necessity for mobile roentgen ray apparatus. Such apparatus has been used by the French, English and Italian armies not only in order to give roentgen ray service to temporary hospitals where no current is available, but to furnish one or more additional roentgen ray plants to forward hospitals during times of great stress.

Both the French and English have depended entirely upon coil and interrupter to furnish the high tension current. The interrupter is usually of the gas-mercury type. Valve tubes are invariably used, and the roentgen ray tubes are the ordinary gas tubes. The use of Coolidge tubes is still quite limited in Europe, and so far as I have been able to learn they have never been used there with portable apparatus, except that furnished by our own Medical Department.

The primary current supply for this apparatus has been furnished in one of two ways: either from a gas-electric set, with or without storage batteries, or from a dynamo operated by the engine of the automobile in which the apparatus is transported. Fig. 1 shows the official

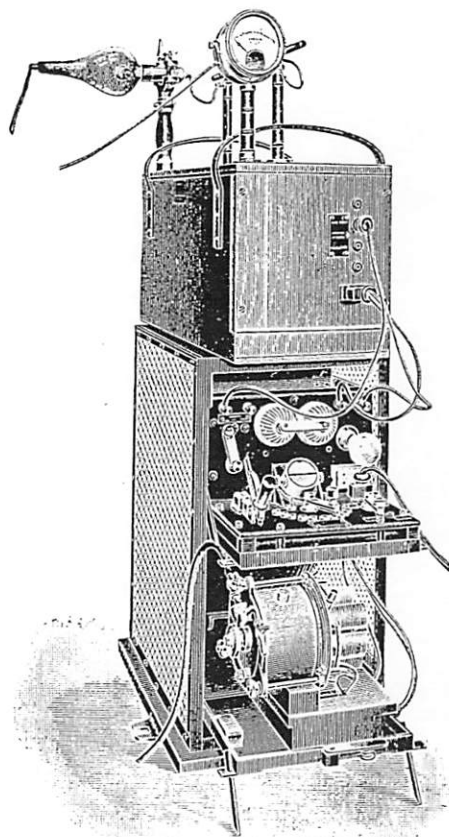


FIG. 1. ENGLISH PORTABLE APPARATUS OF 1915. COIL, INTERRUPTER AND CONTROL TABLE ASSEMBLED.

English type of portable apparatus of 1915 which receives its current supply from the gas-electric set shown in Fig. 2. This is a water cooled gas engine with direct connected dynamo delivering a current of 10 amperes at 60 volts when run at its normal speed. Storage batteries are a part of the apparatus, and by connecting them in

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series with the dynamo a current of 10 amperes at 100 volts may be obtained. This combination makes it possible to obtain 4 or 5 milliamperes through a tube of medium hardness.

Fig. 3 shows the latest type of English apparatus set up ready for operation. The canopy extension connected to the automobile serves as a fluoroscopic room. The

Equipage Radiologique with the mercury interrupter on a shelf by the driver's seat and a gas-electric generating set mounted behind the driver's seat. The latest type of French roentgen ray automobile outfit has been described as follows by Lt. Col. P. M. Hickey:

"It consists essentially of an ordinary automobile with a large box body, which

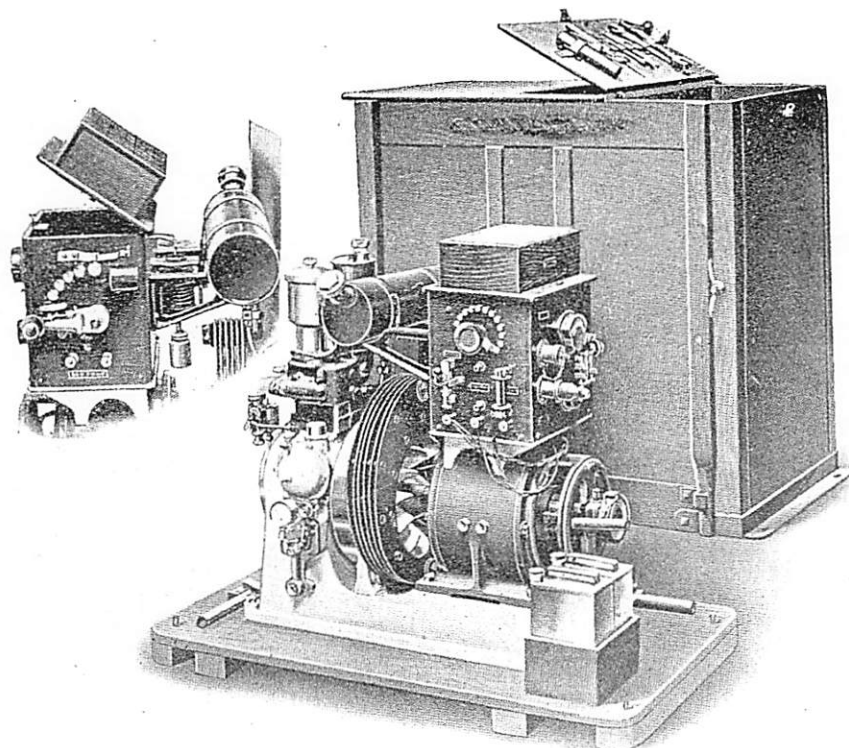


FIG. 2. GAS ELECTRIC SET OF ENGLISH PORTABLE APPARATUS.

body is thoroughly equipped as a dark room. The power for the roentgen ray apparatus and electric lights is supplied by dynamo operated by the motor of the truck.

The French service has also depended upon the coil and interrupter actuating a gas tube, and for generating apparatus has used a dynamo driven by the automobile engine, or in some cases a separate gas-electric set. The output of such apparatus is about 10 milliamperes through a medium tube. Fig. 4 represents the French

is equipped to serve as a dark room and for storage of tables, etc. The essentially new part of the outfit (Fig. 5) is that the chassis in its forward part is of a peculiar construction. Instead of terminating directly under the forward part of the hood, the front end of the chassis is elongated with a U-like projection of very heavy material. This U-shaped projection serves for the mounting of the dynamo. This dynamo is mounted on a prolongation of the axis of the crank shaft of the motor.

The dynamo is rated at $4\frac{1}{2}$ K.W. There is a second low hood which covers the dynamo without disturbing the hood which covers the engine proper. The engine is a 4 cylinder machine rated at 25 H.P. The dynamo is designed to furnish current for lighting the mobile hospital unit and also to operate the roentgen ray apparatus. The interior of the body is quite spacious, the forward part being devoted to dark room equipment. On the left side are racks for drying, in the center is a commodious sink, and on the right a large washing box. On either side of the rear entrance are large well fitting cupboards with double locks

There is also room for the tube carrier which goes under the operating table." (The table, tube carrier, and other accessories are shown in Fig. 6.)

When the United States entered the war the only type of portable roentgen ray apparatus in use by our army was one consisting of a very heavy gas engine operating a dynamo, the latter having a disc on its shaft to revolve in contact with brushes connected to the terminals of a high tension transformer. This apparatus was cumbersome and its output small.

It was necessary to decide whether the portable apparatus to be adopted by our

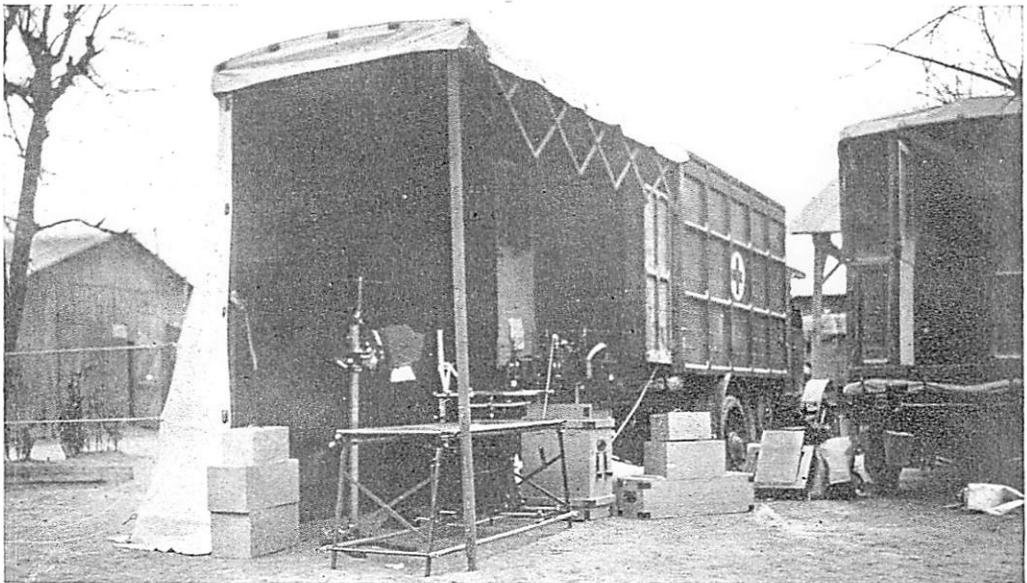


FIG. 3. LATEST TYPE OF ENGLISH ROENTGEN RAY CAMION.

containing places for chemicals and various accessories. The roentgen ray tubes and valve tubes are carried in specially designed boxes which can be placed on each side of the body. There is a demountable aluminum top table which folds up and occupies very little space. There is also carried the regular French military demountable table for fluoroscopic localization. There is abundant room within the body for one of the portable Ledoux-Lebard outfits consisting of a coil and mercury interrupter.

medical department should be complete in itself with a separate gas-electric generating set, or whether we should depend upon the motor of the automobile for power. A number of reasons, based upon reports of American military observers, influenced the Surgeon General's Office to adopt a portable outfit having a separate gas-electric set. It was observed that automobile engines, not being constructed for this kind of service, got out of order very frequently, not only interfering with

the operation of the dynamo for roentgen ray work, but resulting in frequent delays on the road due to motor trouble. After a heavily loaded truck has been driven a considerable distance, possibly over difficult roads, time must be given to overhauling the motor if it is to be kept in good working order, and of course this cannot be done if the motor is run con-

tension transformer instead of the coil with the troublesome interrupter, but also eliminates the synchronous motor and revolving devices for rectifying the current. Fig. 7 shows the apparatus without the gas engine, set up in connection with the portable table. Actual practical work under the difficult conditions of war has demonstrated that this is an entirely satis-

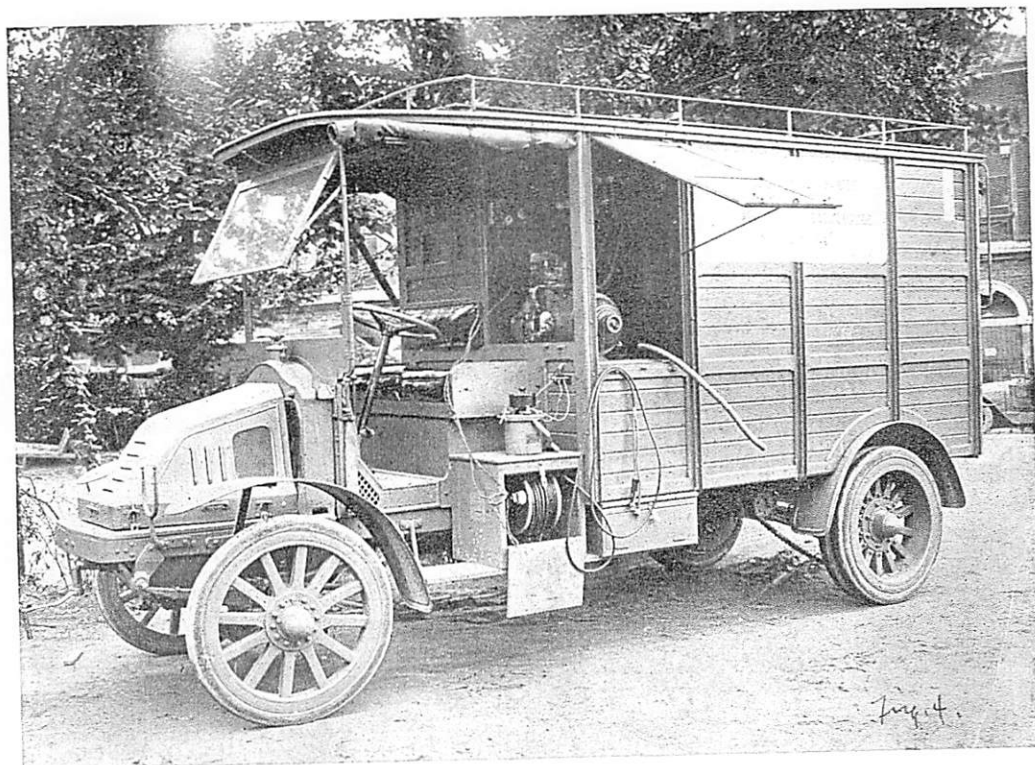


FIG. 4. EARLIER TYPE OF FRENCH ROENTGEN RAY CAMION.

tinuously to operate roentgen ray apparatus after arriving at its destination. Another consideration is that accident to the motor on the road results in disabling the entire roentgen ray outfit, since it depends upon the automobile motor for its power.

The portable apparatus adopted by the medical department is that developed by Dr. W. D. Coolidge. It derives its great advantage over other portable apparatus from the use of a special radiator type of Coolidge tube which rectifies its own current. It permits us not only to use a high

factory portable outfit. It is true that the maximum output is only 10 milliamperes, but the very fine focus of the new radiator tube makes it possible to do perfectly satisfactory roentgenography of all parts of the body. I will give no detailed description of the apparatus here since it has already been described by Dr. Coolidge, and description of its construction and operation will be found in the U. S. Army X-Ray Manual.

After this apparatus was decided upon it was necessary to determine the type of vehicle in which it was to be transported,

the method of packing, and what accessories were to be furnished. It seemed very desirable to choose, if possible, some standard medical department vehicle instead of devising an entirely new outfit. An automobile which was already standardized could be much more readily secured in sufficient number, and the problem of spare parts and repairs would be greatly simplified. The standard U. S. Army automobile ambulance seemed suited to our

ard body are removed, and also the devices for supporting the army litters. Across the front of the body, immediately behind the driver's seat, tying the sides together, is a platform of 2" plank upon which is securely bolted the Delco gas-electric set with its switchboard, etc., complete. (Fig. 8.) This plank mounting acts as a spring support for the engine and reduces the vibration to a minimum. Packed in the interior of the body are the parts of the

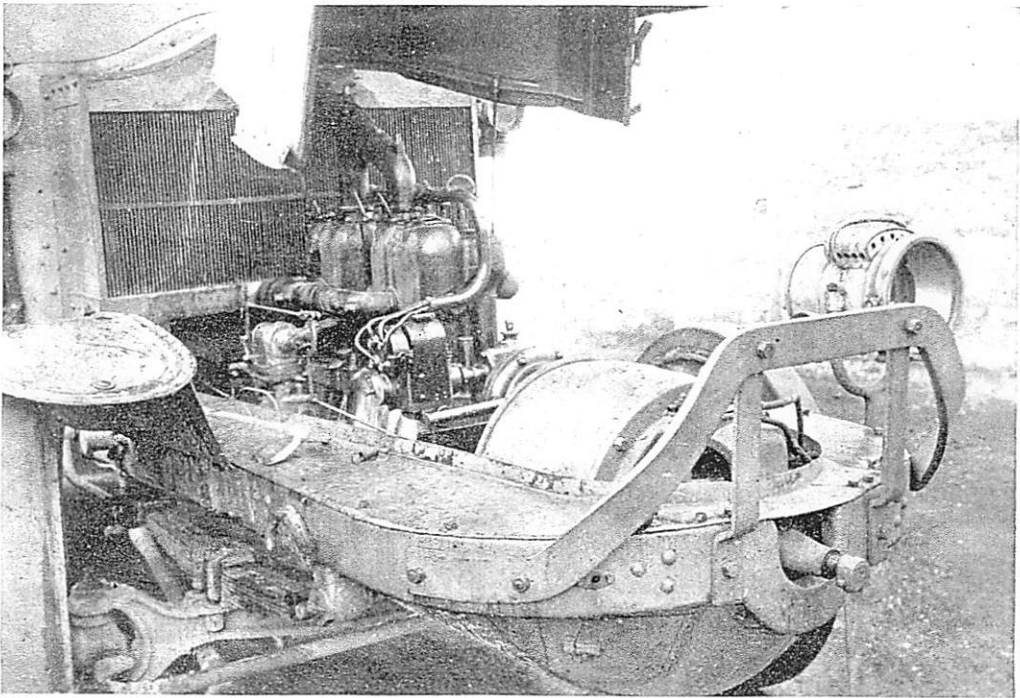


FIG. 5. LATEST TYPE OF FRENCH ROENTGEN RAY CAMION, SHOWING MOUNTING OF DYNAMO IN FRONT OF ENGINE.

purpose and it was found after some experimentation that it could easily be modified so as to carry safely and conveniently the entire roentgen ray outfit with all necessary accessories. This modification was carried out under the direction of Lt. Col. George C. Johnston, M. C., U. S. A.

The standard army ambulance is mounted on a three-quarter ton chassis. It was modified in the following manner to transport the portable roentgen ray apparatus:

The seating arrangements of the stand-

portable roentgen ray table, the roentgen ray tube box with its shutters, a portable dark room, an army bedside unit to serve as a spare roentgen ray apparatus, a carrying case for the radiator tubes, the box containing the high tension and Coolidge tube transformers and all the other electrical parts of the portable apparatus, and a box of the standard localizing apparatus. The chemicals, trays, films and other dark room accessories are contained in the portable dark room mentioned above. There is also provided a light-tight canopy with a

gaspipe frame for its support which can be erected within any building at hand, or, if necessary, in the open, to serve as a

tains of the ambulance are longer than usual and are provided with end flies. The supports for the table tops are hinged and

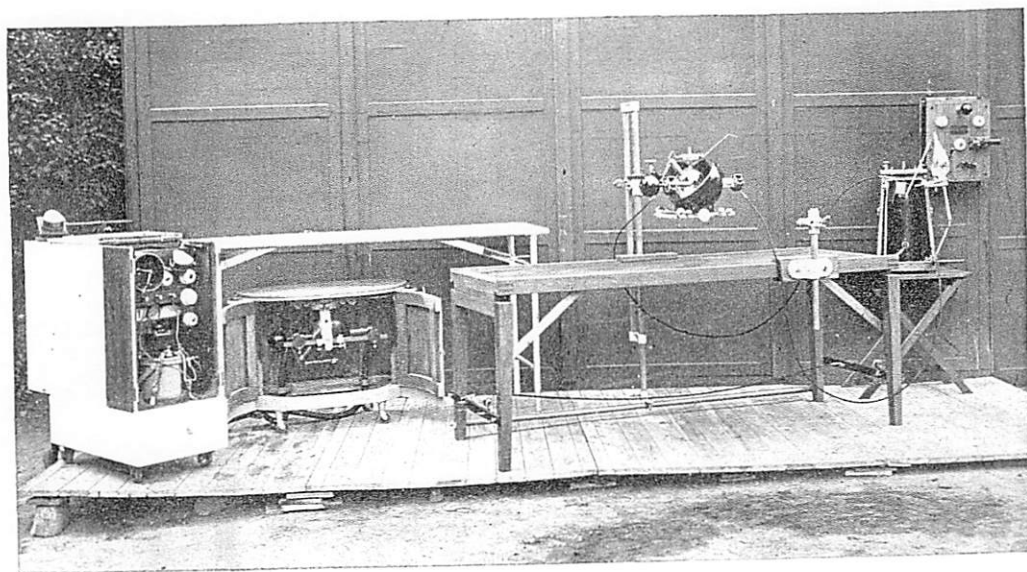


FIG. 6. FRENCH PORTABLE APPARATUS.

fluoroscopic room. All of this apparatus rides safely in the modified ambulance

may be dropped down to the horizontal. The side curtain having been drawn over

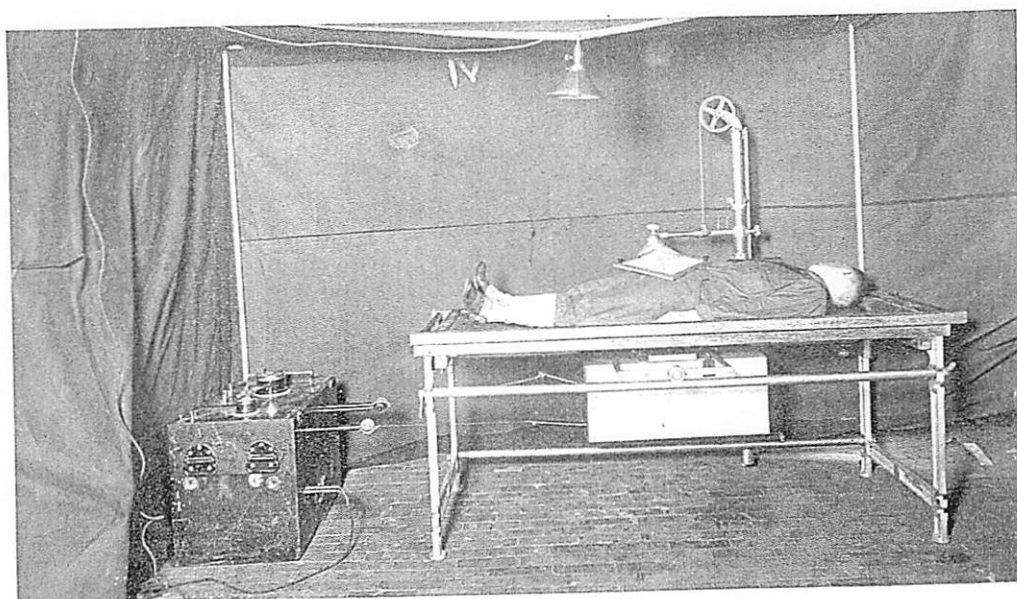


FIG. 7. AMERICAN PORTABLE APPARATUS WITHOUT ENGINE.

and does not overload it. On the sides of the body are carried three wood bakelite tops for the portable table. The side cur-

the table tops and the end flaps fastened beneath them, there is provided an excellent pair of tent covered cots upon which

the chauffeur and technician may sleep. (Figs. 9, 10.) The officer in charge can sleep on the third table top placed on top of the apparatus inside the ambulance.

This outfit was adopted by the Surgeon General's Office after a 2,000 mile road test. It was found practicable to do the entire work of one of our large cantonment hospitals with it when the hospital's appa-

ray work with that army. Lt. Col. Merritt's previous experience in charge of roentgen ray work with the First Army during the time of its active operations renders his judgment on this matter of particular value. His report states that the modified ambulance is entirely satisfactory as a means of transporting the roentgen ray apparatus, with the exception of a few

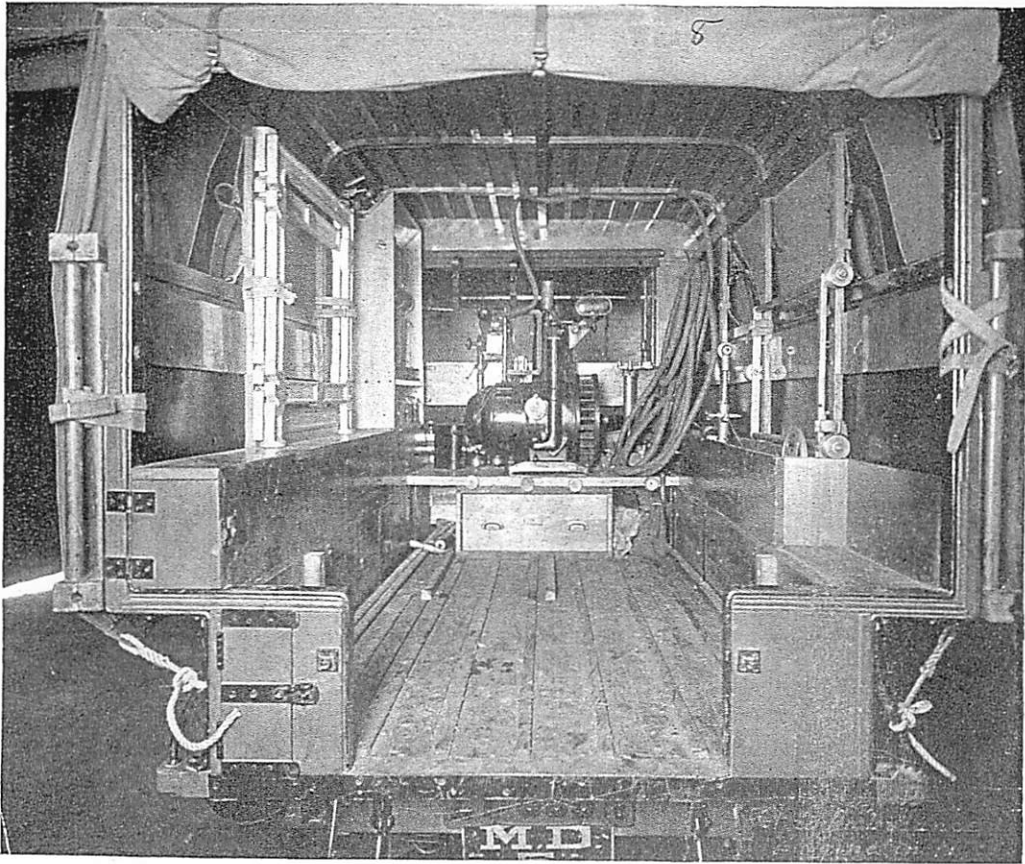


FIG. 8. AMERICAN CAMION WITH ENGINE MOUNTED BEHIND DRIVER'S SEAT.

ratus was out of order. The roentgen ray apparatus itself has been thoroughly tested both in this country and in France.

Unfortunately, our modified ambulances did not reach France in time to be placed in operation until after the beginning of the armistice. They have been very thoroughly tested, however, in the Army of Occupation by Lt. Col. E. A. Merritt, M. C., U. S. A., who had charge of roentgen

minor changes. The rear tires must be heavier than those on the standard ambulance, and the rear springs must have one extra leaf. All these camions sent to the Army of Occupation were provided with an extra Delco engine to be used for lighting purposes, and with wiring and bulbs for thirty-five lights. It was found by experience that field and mobile hospitals practically always depend upon the roentgen

ray department to furnish lights. Even evacuation hospitals depend upon the engineer department to furnish the necessary

to provide current for lights until the engineering department is able to install a plant. In the French and English camions



FIG. 9. AMERICAN CAMION WITH TABLE TOP ARRANGED FOR SLEEPING.



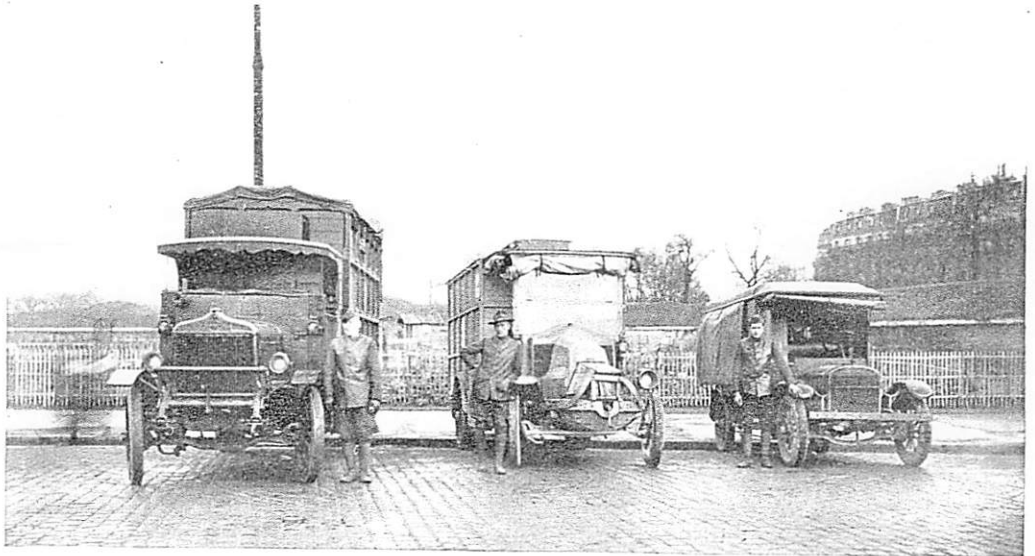
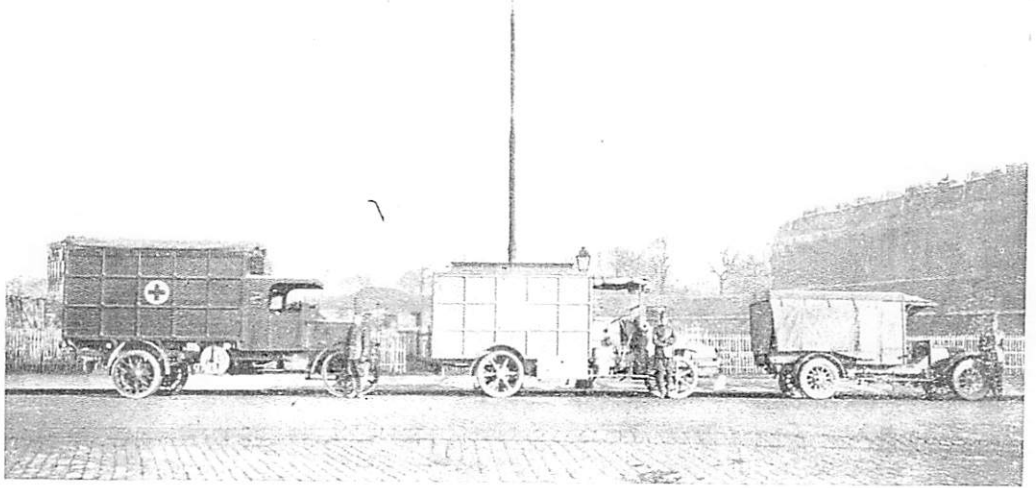
FIG. 10. AMERICAN CAMION READY FOR THE ROAD.

lighting outfits, and in numerous cases the roentgen ray generating outfit has been used for the first twenty-four or forty-eight hours

the lights are supplied with current from the same dynamo that furnishes power for the roentgen ray machine. Experience

showed that this was not satisfactory. There was often great variation in the current to the roentgen ray tube depending upon the number of lights in use, and at times there was lack of penetration due to

ary Forces, to equip our mobile hospitals with the French camions described above. Most of these were equipped with the standard French apparatus, but a few of them were furnished with the American



FIGS. 11 AND 12. ENGLISH, FRENCH AND AMERICAN CAMIONS, IN ORDER LEFT TO RIGHT.

overloading the line. These objections are eliminated by the use of an extra engine for lighting purposes alone.

Because of the late arrival of our own camions in France, it was necessary for Lt. Col. Case, Senior Consultant in Roentgenology with the American Expedition-

portable outfits. Excellent work on many thousands of cases was done with the French apparatus. The mercury interrupter, however, was a source of great annoyance, and the use of gas and valve tubes is of course much less satisfactory than the Coolidge tube.

Comparison of the English, French and American camions may be made by reference to Figs. 11 and 12. It will be seen that the American type is much smaller than either of the others. Fully equipped, it weighs about half as much as the French and about a third as much as the English.

The advantage of the English and French camions over the American is that the two former have the body of the car arranged for a dark room, while the latter has not. Experience in this war has shown that the greater part of the roentgen ray work in all hospitals in the forward areas, including evacuation hospitals, is fluoroscopic. An elaborate dark room is therefor unnecessary. The few plates that will be made can be conveniently developed in the small portable dark room furnished with the American apparatus.

The advantages of the American type of apparatus which are now apparent are as follows:

1. The automobile engine is not used to generate power for roentgen rays or lights, and can therefore be overhauled and placed in order between trips.

2. It is much lighter than the English and French types, and has a powerful engine rendering it very mobile. It is doubtful if the heavy types of camions could be operated to advantage over roads less good than those in France.

3. It is essentially the United States Army Ambulance, for which extra parts are carried in stock by the Army.

4. The apparatus is demountable, and can be placed in another camion or even in a truck and taken to its destination, if the original camion gets out of order.

5. The roentgen ray apparatus carried in this camion is not of special type but is the standard Army Portable Outfit.

6. Experiment has shown that the roentgen ray efficiency of the American portable apparatus is approximately eight times that of apparatus depending upon a coil and interrupter and gas and valve tubes.

It is believed that the American portable apparatus carried in the modified ambulance described above, with a few minor modifications tending to simplify it, is the most satisfactory mobile roentgen ray outfit yet devised.