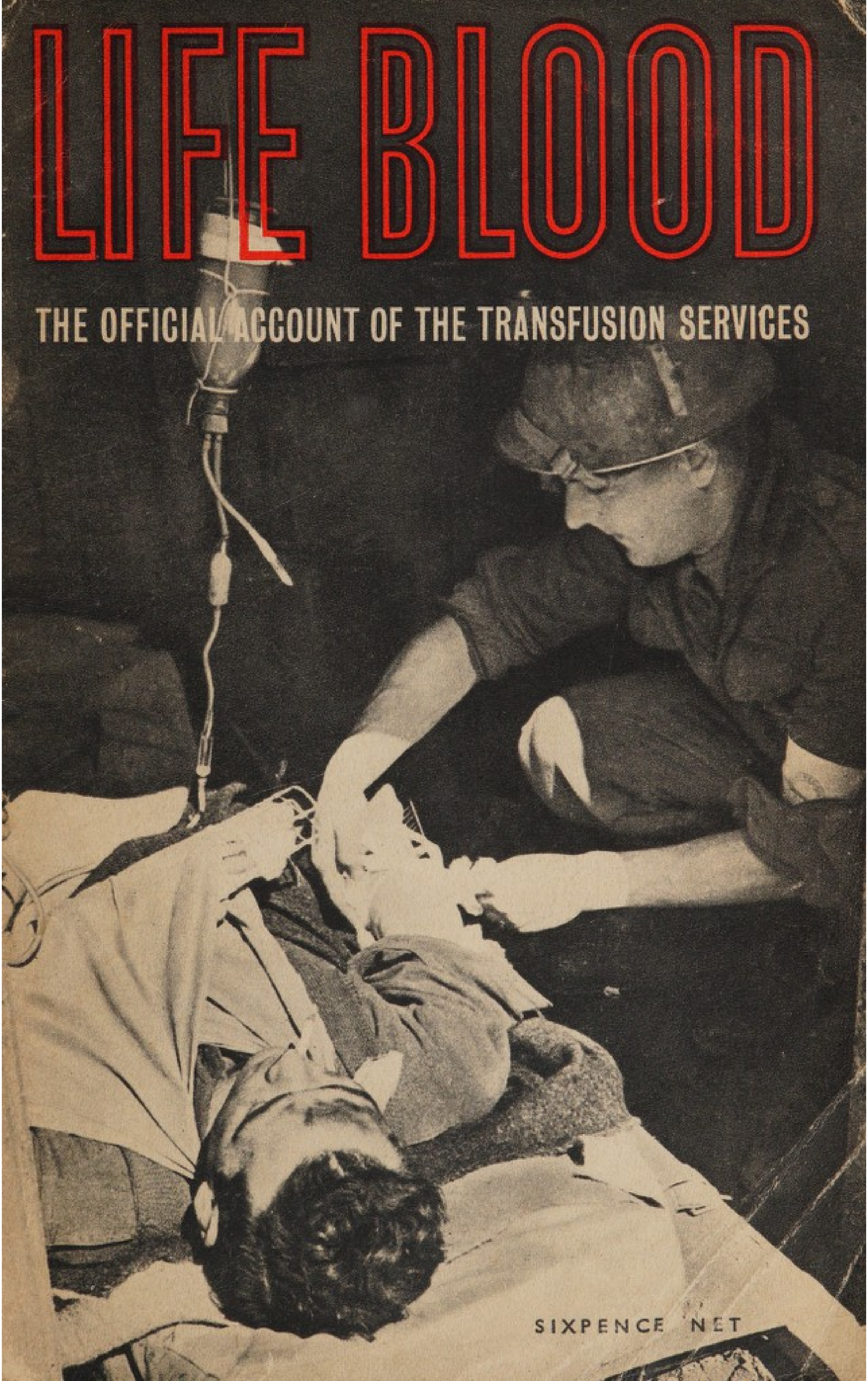
LIFE BLOOD

THE OFFICIAL ACCOUNT OF THE TRANSFUSION SERVICES



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Life Blood

The Official Account of the Transfusion Services

Prepared for the Ministry of Health

and the Department of Health for Scotland

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In no cases have the real names of the donors and recipients mentioned in this book been given.

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1 From Blood-Giver to Battlefront

WHEN, on the morning of the 6th June, 1944, the news reached every home, office and factory in Britain that the invasion of France had begun, three questions came to our minds. How will it turn out? Will the casualties be very high? Will *he* come through all right?

There were many casualties; but far fewer than had been expected. One fact stands out—many wounded men were saved on the Normandy beaches who would have died in similar conditions in the last war. And one of the chief reasons for the low death-rate among casualties was that the men in the landing craft, the ships, the transport planes and the gliders took with them blood given by men and women in towns and villages all over Britain. Strapped into the equipment of the medical units of the paratroops and all other assault units were bottles of the blood product, plasma, and transfusion sets, in waterproof boxes. Transfusion Officers with the assault troops carried waterproofed instruments and dressings, so that, without waiting for their special lorries to be beached, they could set to work dripping life blood into wounded men.

Soon after the transfusion teams had waded ashore came Field Transfusion Unit lorries, equipped with refrigerators. In the refrigerators were 1,100 pints of fresh, whole blood. Blood plasma was also carried in other military vehicles—slung on the underside in containers which in the ordinary way hold trench mortar shells; four bottles and two transfusion sets took the place of three shells.

So not only the thoughts and hopes of those at home went with the fighting men to Normandy. Their gifts of blood went too. Here are two of the first messages telling how that blood was used. The first is from a Field Transfusion Unit Officer:

"We arrived at the appointed time without mishap. We were running our resuscitation ward in the local Mairie within an hour of arrival. My two orderlies have proved themselves extremely efficient. We were too busy to keep any records the first forty-eight hours, but at the end of that time I had about a hundred empty bottles which had contained blood or plasma—rather more the latter than the former. The refrigerator is running well. One of the first casualties I saw was an old friend with a penetrating wound in his chest. He was doing quite well when I last saw him."

The second message is from an Advanced Dressing Station:—

"A Highlander who had been lying in a field for three days with a shell splinter in his chest before the stretcher bearers found him was pulseless when admitted. At first the doctor despaired of his life. A Transfusion Officer decided to give him a transfusion. After he had been given four pints of blood, he revived and started to relate his experiences. . . . A lance-bombardier who had had both legs shattered by an 88 mm. shell was given a transfusion within fifteen minutes of becoming a casualty."

As the troops fought their way inland, supplies of blood and blood products followed them, and continued to follow them day by day. More plasma, in round wicker baskets, was dropped by parachute to airborne troops and isolated units.

The invasion force's first reinforcements of whole blood, carried in insulated boxes on landing craft, began to cross to France a few hours after the invasion. On D + 14, daily air transport began. Blood given by civilians in England one day has sometimes been used on the battlefield the next.

Plasma was still sent by sea. Before D-day, blocks of maintenance-supplies had been built up at an Army medical store in England. Each block represented the estimated daily needs of plasma for the whole invasion force. Every day after D-day, one of these blocks was transported to the beaches ; and all the way to Germany, supplies of blood and plasma have followed the fighting men.

No force has ever been better equipped for transfusion (or for other medical services) than the Army of Liberation. The methods of carrying the blood and transfusion sets were improved and elaborated as the result of experience gained in the Sicilian, Salerno and Anzio landings. Other changes were made in the organisation because of the nearness of the battleground to the home base. For instance, more refrigerated whole blood was used in proportion to the blood products, dried and liquid plasma, than in the campaigns in Italy, the Western Desert, Greece and Crete.

Transfusion on the Sicilian Beaches

Let us look for a moment at the part blood transfusion played in the first invasion of Hitler's "Fortress of Europe"—on the 10th July, 1943.

One in thirty of the first 300 men to land on the Sicilian beaches was an R.A.M.C. man, carrying on his back a tall, round tin containing a pint of liquid plasma and a transfusion set. Although the opposition was less than had been expected, casualties soon began to come in to the improvised first aid post. Some of these men had suffered damage to arteries, or had had their legs fractured by machine-gun bullets. Within an hour of the first men coming ashore, serious casualties of this kind were receiving transfusions. In almost every case the seemingly lifeless body began to revive. It was like putting a half dead flower in water on a hot day.

Meanwhile, a party of sixty men forming a Field Service Unit had landed more elaborate equipment from a special boat. An hour or so later a really large dump of medical stores had reached the shore. Among these stores were 300 bottles of plasma. They were followed by the Field Transfusion Unit and the Casualty Clearing Station ; and off-shore lay a hospital ship with 200 pints of blood held in reserve. As the advance continued, the R.A.M.C. men kept well up with the foremost parties. Wherever resistance was met, they at once looked round for shelter—perhaps a half-ruined cottage or an overhanging rock—and established a first aid post ready for action. The work of saving life in the midst of death and destruction went on. . . .

The Blood-Givers

It is four o'clock on a Thursday afternoon in a small town somewhere in England. The scene is a bare Parish Room, nothing very interesting about it, except perhaps the pockmarks on the plastered walls and the patches in the roof, souvenirs of some night of blitz.

A few people are walking up the chipped steps, each with a little card in his or her hand, and taking their places on a row of chairs, in front of which is a low screen hiding the rest of the room. They glance at one another, and one or two nod or even (though they have never been introduced) go so far as to pass the time of day.

A careless observer might suspect that these are applicants for a job of some sort—though it is hard to imagine what job could be suitable at once for a large, middle-aged woman, a soldier, a workman, a young red-haired girl of about twenty, an elderly man with an A.R.P. badge and a limp, and a railway goods guard who has brought his lamp along with him, as he proposes to go on duty directly his visit is over.

Though it is nobody's business, let us give a few facts about these people, just sufficient to explain why they have come here, why they are about to lie down on beds, to roll up their sleeves and each to have a pint[1] of blood removed into a bottle.

The large, middle-aged woman is Mrs. Alice Edwards, a widow, with one son in the Army, a daughter in the A.T.S. and three others at home. Mrs. Edwards can always be relied upon to find half-an-hour here and there to help win the war. That is why she answered the appeal for blood donors a year ago. Besides, she found after her first donation that a little blood-letting seemed to do her good, to overcome a feeling of heaviness, and she comes now every three months—" for her own health ", so she says.

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[1] Throughout this book the blood gift is referred to as " a pint". In practice it is usually three-quarters of a pint.

The soldier, Corporal Evans, is home on leave. He can never forget how his best friend, just before they were evacuated from Dunkirk, had the lower half of his body crushed by some falling masonry. The corporal had helped to get him to a dressing station and had watched on the beach while the medical officer dripped in a pint of blood. The thing that stuck in the corporal's memory was the way in which Tom's almost lifeless form revived as some unknown person's blood began to refill his veins. Ever since then, whenever he comes home on leave, Corporal Evans repays the debt for his friend.

The workman is known to nearly everybody as Jim. Jim and his mate were working overtime repairing a sixty-foot-deep tank in a munitions factory. It was hot work, but if it hadn't been for the long hours, Jim's mate, the steadiest worker you could wish to meet, wouldn't have misjudged his balance and fallen in. As it was, Jim's mate was picked up by Jim and some others at the bottom of the tank, with his pelvis broken, the base of his skull fractured, three or four ribs crushed in, and a good many face wounds, including a slit from end to end of his nose.

When they got Jim's mate to the County Hospital he had neither breath nor pulse, but it was decided to try the effect of a pint or so of plasma. Earlier this Thursday afternoon Jim had been to see his mate, still lying in the hospital. All the bones were healed, he was able to sit up in bed, and to talk about being back on the job. His life had been saved by the blood of no fewer than twenty-three donors. He was not only alive, but going to be useful again. Sooner or later a plastic surgeon would give him a new nose but, as he told Jim, " I've had so much done to me that I don't want anything else done yet ". Jim has come to return some of that blood. " After all, it might have been me," he says.

The young red-haired girl of about twenty, Mabel Adams, makes parachutes. This is her afternoon off. Her reason for being here is very simple. One day she is going to marry a young man at present kept very busy with the Eighth Army. He wrote and told her that the Eighth Army needs blood. A couple of his pals had been blown up while clearing a minefield, and they'd told him all about the transfusions they had been given.

The elderly man with an A.R.P. badge prefers to keep his name to himself. You will notice when his turn comes to go behind the screen that he limps badly. He was seriously wounded in the last war. He lay for month after month slowly recovering, his wounds washed day after day with a constantly dripping antiseptic fluid. But he had nearly died from loss of blood before they could do anything for him at all. He tries to forget all this, especially when he thinks of his three sons, all in the fighting forces. It is a great consolation to him when he realises that if they get wounded, they need not suffer as he suffered, thanks, among other things, to modern methods of blood transfusion.

Finally, Harry Robinson, the railwayman, knows what happens if a man gets crushed between two trucks on shunting operations—or smashed in an air raid. It might happen to him. Anyway, a pint of blood every now and then is the least one can give to the unlucky ones, he thinks, and a sort of insurance for the giver, too. " For all you know, they may be pumping it back into your own body one day."

Well, there they are, these six ordinary men and women, samples of the million and four hundred thousand men and women who have enrolled as blood donors from one end of Britain to the other. What is it they give ? Why is their gift so precious ? How is it used ? Whose lives do they save ? This book will answer these questions.

All over the country people like Mrs. Edwards, Corporal Evans, Mabel Adams, and Jim, with very little trouble to themselves, have given their pints of blood. In every one of the fighting forces at this moment, and in all the bombed towns and cities, there are men and women who owe their lives to these gifts. Not only that. In many a town in Britain men and women are walking about and doing vital war jobs who, though not war casualties, would quite certainly be dead but for the Blood Transfusion Services.

2 What is Blood?

TO Jim and Mabel and Corporal Evans and the rest, their blood is a bit of a mystery. They probably imagine it as a warm, red fluid like red ink, but thicker and darker. Blood is not in the least like that. Part of it, it is true, is a fluid, but the fluid is not red ; it is almost transparent. In this transparent fluid, called plasma,[1] move millions

[1] " Plasma" and " serum " are both used for transfusion purposes, though for simplicity this book refers to " plasma " only. This is a technical description of the difference between them :—

Blood which is shed or withdrawn from the circulation, and left to itself, separates into a solid mass or clot, consisting of the cells entangled in " fibrin", and a liquid containing the blood proteins other than those concerned in fibrin formation. This liquid is *serum*.

Blood withdrawn into an anti-coagulant, such as sodium citrate, does not clot. The cells settle to the bottom of the container, leaving a clear fluid above them. This fluid contains all the blood proteins, including those concerned in fibrin formation, and is called *plasma*.

of solid bodies, passengers of one sort or another hurrying along the high roads called arteries and veins. Most of these passengers are red, or look red when we see a few millions of them together, and others are colourless or pale. Many of the passengers travelling along the blood highway are completely invisible, but we know of their existence because of what they do.

For tens of thousands of years men and women have had surprising ideas about blood. They have been terrified of it, they have worshipped it, they have thought it able to work all sorts of miracles. False ideas about blood have led men to perform the most atrocious cruelties, to believe in the strangest myths about their fellow creatures, to have many romantic illusions.

Men have killed one another in the belief that a sacrifice of human blood was needed to maintain the strength of the cruel idols they worshipped. Savages have sealed lifelong friendships by drinking one another's blood. Racial theories as evil as those believed in by the Nazis have attributed to the blood of individual men all sorts of good and bad qualities which it does not possess. (These theories have sometimes killed those who held them, as when German prisoners in this war have refused blood transfusions for fear that non-Aryan blood might be dripped into them to poison them.) Men have tried to increase their own courage and strength by drinking the blood of wounded heroes.

The fact that people have believed such things for countless generations does not make them true. There is, for instance, no truth whatever in the idea that one man's blood can change or influence another man's character. But when all the dreams and nightmares that mankind has had about blood have been recognised for what they are, the reality remains more remarkable than any fiction.

There Must be No Mistakes

The reality is this. Your blood, introduced into a sick or wounded man's veins, may be his one chance of life, but on the other hand may mean certain death for him. Your blood is one man's medicine and another man's poison. The careful use of your blood, if you give a pint of it this afternoon, can save someone's life. The careless or ignorant use of it might destroy a life. That is one of the many reasons why the story of blood transfusion is so fascinating. It is why the men and women responsible for the Transfusion Services have to be so skilful, so accurate, so conscientious in every detail of their work.

Now, what is blood ? First of all there is the fluid or plasma. Its chief function is to supply a means whereby the " passengers " floating in it can be sent in the course of their journeys into every nook and cranny of the body, to every tissue and cell. From before birth until the moment of death the heart incessantly pumps this fluid round and round the arteries, little capillary blood vessels, and veins, to supply every cell in the body. The heart and the blood plasma are a transport system. The heart supplies the power, while the plasma is the vehicle in which the passengers are carried.

In case of serious injury, there will probably be a loss of passengers and a loss of plasma. The circulation will be upset and the passenger service disorganised. Sometimes, therefore, your blood is required to make up for the loss of someone else's blood plasma. It is probable, in fact, that a man whose life depends on a blood transfusion is dying through lack of plasma—that is, from the effects of shock—rather than through lack of the valuable passengers. His traffic system has broken down and the passengers are stranded and unable to get to their proper destinations. Now, what are these passengers ?

Millions of Passengers a Minute

Some of the most important from our point of view are the red blood corpuscles, tiny little discs, about five million to the cubic millimetre ; when seen alone under the microscope, these turn out to be yellow, but they give blood its characteristic red colour. These red blood cells, although they float in the bloodstream, are just as much part of the body as any other tissue. They are manufactured in the middle of those bones which contain red marrow, especially the bones of the backbone, the skull, the ribs, the pelvis, and the top ends of the long bones of the legs and arms. This red marrow develops into several different kinds of cell, of which the red cells are the most numerous.

Having been conveyed along the little capillaries of the bones into the circulatory system, they live there performing a very special work for from three to four weeks, and then they are worn out and their now useless remains are filtered out of the system, or salvaged to make new cells. The special duty which they perform to the body as a whole is that of carrying oxygen to every cell. Don't imagine that all your breathing is done by your lungs. When you take a deep breath of fresh air, you say you are filling your body with oxygen, but of course the act of breathing fills only the lungs. The oxygen must not stay in your lungs ; it must be distributed to every part of the body.

It filters through the delicate membrane, and each blood corpuscle passing that way takes up its quota of oxygen, and hurries along, propelled by the heart, through arteries into the tiny capillaries, sooner or later depositing the oxygen in one or other of the millions of cells from the crown of the head to the soles of the feet.

Having done this, the blood corpuscle picks up in exchange carbon dioxide, a product of the cells' mode of living, and finds its way back along the veins through the heart to the lungs once more. Here it gets rid of its carbon dioxide, which you breathe out into the air again. Then with your next breath it once more gets its oxygen and repeats its journey. And so if a man, through accident or disease, loses a large proportion of his blood corpuscles, his tissues will very soon die of asphyxiation. The cells do not get their oxygen, and that is, in a way, the same to them as it is to a drowning man when his lungs cannot get oxygen because his head is below water.

Transfusion Restores the Transport System

Thus, there are two main ways in which blood transfusion can save life ; first, by supplying lost plasma, that is, the lost transport system carrying the blood corpuscles round the body ; secondly, by supplying the red blood cells themselves, when for some reason the body has not sufficient. This deficiency may come about because of serious hæmorrhage from a wound, or because something is wrong with the red bone marrow or other parts of the body which play a part in the making of blood cells, so that new blood cells are not being made as the old ones die.

Besides the red blood cells, there are many other passengers moving in the blood plasma. There are white cells, some of which destroy the germs of disease when they enter the bloodstream from the outside world. There are various kinds of nourishment, distilled by the digestive system from food and sent to nourish remote parts of the body. There are minute quantities of chemicals produced by the ductless glands.

There are other passengers, even more mysterious—so mysterious, in fact, that scientists prefer to call them by letters of the alphabet because they do not know what they are. What they do is well enough known now. By their presence or absence they divide human beings into four separate groups. Everybody's blood belongs to one of these four blood groups, and until tests have been made to find out to what groups a donor and a recipient belong, it is not safe to mix their blood.

There is only one of these four groups which can be safely mixed with blood not only of the same group, but also of the other three. For reasons we shall consider later, donors who have blood belonging to this group can give their blood to a recipient belonging to any of the four groups, but if their blood belongs to any of the other three groups, it would be deadly to the majority of human beings.

If you are a blood donor, you will know already that your blood has been grouped according to the presence or absence of these invisible passengers, and you will know that this grouping has been done in order to make quite certain that your blood is not given to the wrong wounded man.

Giving, grouping, using the gift—all require an organisation, and more than an organisation—a Service.

3 Transfusion: A Life-Saving Service

FOR a moment let us glance at the way in which the British Blood Transfusion Services have grown up. As might have been expected, they have grown up very much as other things grow up in Britain—by the hard work of individuals and without any ordered pattern imposed from above.

In some countries before the war there was a professional system of obtaining the necessary blood. Registered donors were paid so much a pint. The experience of Russia, and later of Spain during the Civil War, made people realise that Blood Transfusion Services should be on a national scale.

In 1921 the Camberwell Division of the County of London Branch of the British Red Cross Society began the transfusion service in Britain, when four of its members responded to a request for blood for an emergency case. The London Rover Scouts were one of the first groups to include blood donation as a form of service. Gradually, the need for a more widely-organised donor service became obvious. At the end of 1925, a Committee representing hospitals, the medical profession, the donors, and the British Red Cross Society was set up. Donor panels were organised in other large cities also. In 1938, seventeen years after its foundation, the London Service was able to answer over 6,000 calls for blood. Several of the donors had by then given blood on more than fifty occasions.

In 1936 civil war broke out in Spain, and a Catalan doctor in Barcelona, inspired by what had already been done in Russia, organised a blood store which served casualties in the Barcelona air raids and also on the field of battle.

By September 1938, most people realised that the experiences through which the people of Barcelona had passed might soon be repeated in London, and in the spring of 1939 the Medical Research Council, at the request of the Ministry of Health, prepared for the worst by setting up four blood supply depots at convenient points to cover London and the South-East. There were also local services in the provinces and in Wales, Scotland, and Northern Ireland, supported by local funds and voluntary subscriptions. At the same time a special Army Transfusion Service was set up in the south-western counties to collect blood for the armed forces in the event of war.

The expected air raids did not come when war began. But in the days before Dunkirk and on the evacuation beaches we saw the first large-scale use of the Transfusion Services. In those days blood transfusions were almost always of whole blood, and material for transfusion remained useful for only two or three weeks, and then had to be scrapped and replaced by new supplies. But experiments with plasma were being carried out both here and in America, and its use revolutionised the whole problem.

How Blood is Collected and Where it Goes

After Dunkirk there was no part of Great Britain which could be regarded as immune from air attack or invasion. So the Ministry of Health set up Regional Blood Transfusion Centres in those parts of England and Wales not served by the Medical Research Council or the Army. In Scotland, the Scottish National Blood Transfusion Association had been formed under the auspices of the Department of Health for Scotland to co-ordinate and extend existing services. Besides these, there are the Royal Naval and Royal Air Force teams attached to certain of the civilian centres, which supplement for their own purposes the large quantities of blood and plasma supplied to them by the civilian Services. The Royal Navy has also its own Service to which only naval personnel give blood ; and Canada has sent substantial gifts of dried plasma.

All the different Transfusion Services have worked out their own organisation along lines which have seemed most suitable to local conditions and with the help of the British Red Cross Society, the Order of St. John of Jerusalem, St. Andrew's Ambulance Association, Women's Voluntary Services, Local Authorities, Trade Unions, Boy Scouts, Women's Institutes, Rotary Clubs, Church Societies, and many other bodies.

The different Transfusion Services do not appropriate the blood they have taken and use it solely for the benefit of their own special interests. Broadly speaking, they supply all the various needs, both civilian and military, within their areas. Nor are they content with this : they all supply blood products also to the fighting forces overseas.

Blood, fluid plasma and dried plasma are sent to Overseas Forces, to Home Forces, to prisoner-of-war camps, to Emergency Medical Service Hospitals dealing with Service casualties, air raid casualties and the sick, to the Royal Navy, the Royal Air Force and Allied Forces —anywhere and everywhere, in fact, where blood is able to save life.

Nearly three million gifts of blood have been made and distributed during the war. Figures, however, can give but a poor picture of the reality. We realise much more what blood transfusion means if we consider the individual cases of just a few of those who would have died without it.

Look for a moment at Squadron Leader Jim Duncan. Perhaps you think that his scarred face is bad enough as it is. But you did not see him as he lay in hospital during the weeks following his crash-landing one foggy night in East Anglia. He had been wounded over Berlin, but in spite of his wound he had managed to bring his bomber limping back again. Knowing the hopeless condition the machine was in, he gave the order to his crew to bale out directly they reached the poppy fields of Norfolk. Then, almost fainting, he guided the bomber back towards his airfield, and crashed down through a hedge a few hundred yards away. The leaking engines caught fire, and Squadron Leader Duncan received that terrible new injury which only airmen are likely to know, that burn of hands and face which comes from the intense heat of high octane petrol, far worse than any ordinary burn which doctors have had to deal with before. Air Force Burn left Squadron Leader Duncan practically without a face. But, as so often happens—probably because the man instinctively screws up his eyes so as to protect his eyeballs—the most precious part of his face was not affected.

When a man is brought in suffering from Air Force Burn his only chance is immediate blood transfusion. Burns quickly affect the blood stream. There is no bleeding away of the whole blood as when an artery is severed, but the circulatory system becomes leaky and the blood plasma seeps away rapidly, some of it into the injured tissues, some of it to other parts of the body, because the blood vessels are no longer able to hold their precious contents. The result of this is delayed or secondary shock, collapse of the heart, and death some hours after the burn has been suffered.

The Plastic Surgeon's Ally

Squadron Leader Duncan lay on his hospital bed, wounded and burned, and mercifully unconscious. At the very moment he arrived at the hospital on a stretcher, a movable blood transfusion set was wheeled up to his side. The needle was pressed into the vein in his arm. The plasma began to drip. With the plasma dripping into him he was wheeled to the operating theatre, his wound cleaned and dressed, the fractured limb closed up in an immovable plaster case, the burned flesh cut away from his face and hands, always with the drip, drip of the transfusion set fighting his battle with death for him.

Meanwhile, his own plasma was leaking out and hour after hour more plasma had to be dripped into him to keep him alive. Slowly the gain of blood increased until he began to pull round. Then followed long weeks of healing. But the healing in itself could not give back to Squadron Leader Duncan anything which you and I would call a face. That was left until later.

At last the time came when he was strong enough to stand his second ordeal, the long-drawn-out operation of plastic surgery by means of which, thanks to the almost incredible skill of the modern plastic surgeon, he was given new eyelids, new lips, new cheeks, new nose. Once more, in this second ordeal, blood transfusion contributed largely to success. This man, strong as he was normally, could hardly have borne as he did the modern sculptor in flesh re-modelling his lost features, had not blood been waiting in the store ready to see him through.

From beginning to end, Squadron Leader Duncan required the blood of thirty different donors, and though, as he walks about now, his face is terribly scarred, the result is a good deal better than what might have been, what would certainly have been in the last war.

No less are the ordeals of the soldier who fights on land. The wounds that are suffered by soldiers in this war are often very different from those in the last. A large proportion of them are more severe, which makes it all the more wonderful that a far greater number of men survive them—thanks to improved medical and surgical knowledge. When the final statistics of men wounded in this war and their deaths or recoveries come to be compared with those of the last, it will be found that an enormously greater proportion admitted to hospital now survive.

The four chief reasons for this are the use of penicillin, the sulphonamide and other drugs against infection in wounds, the use of the closed plaster treatment of compound fractures, blood transfusion, and the brilliant new ways of organising the medical services so that casualties can be got to treatment in the shortest possible time.

It is because of these four advances that so many men survive the worst type of wound a soldier can receive. This is the wound caused by an anti-personnel mine exploding under his feet. It is a shattering wound, crushing and pulping the flesh and bones, especially in the lower half of the body. There would have been no chance whatever of survival for such a casualty in the last war.

The Race Against Time

Sergeant Blake, a sapper, is an example of what happens to-day. This young man of 30 years had, as he put it, " the uncommon and startling experience" of watching his leg travelling many yards through the air. He was admitted to an Advanced Dressing Station, given morphia and a pint of plasma. Only four hours later they got him to the Main Dressing Station. He would, of course, never have got there but for the plasma. He was given two pints of blood and then operated on. During the operation, which was a long one, another three pints of blood had to be used.

Sergeant Blake is completely recovered. He has a steel limb now, and although he no longer superintends the finding of anti-personnel mines left behind them by retreating German armies, he is still a useful man. Had he got wounds like this in the last war he could not possibly have lived, even if he had been lucky enough to find himself at a Main Dressing Station supplied with the normal amount of blood, for in the last war the normal amount of blood at a Main Dressing Station was never more than two pints. Besides this, it was the one pint of plasma he was given immediately after his wound, and before he was taken to the Main Dressing Station, that really saved him.

The Tenth Man's Chance

To give an idea of the extent to which blood transfusion has been used, here are some interesting figures from the desert campaign of the Eighth Army. During the battle of El Alamein, 7,393 casualties were admitted to the Main Dressing Stations. One in ten of these had to be transfused to save their lives, and on the average three bottles were required for each casualty transfused. At Agheila there were 1,393 wounded admitted. One in six had to be transfused.

Those are some of the figures for a few of the battles in the Middle East campaign. The figures for the British North African forces are almost exactly the same. Ten per cent. of the 16,000 wounded were transfused, and on the average three bottles were required for each casualty needing blood or plasma.

A very large proportion indeed of all these casualties needing transfusion was due to the explosion of anti-personnel mines. Here is an extract from a letter from a Field Transfusion Unit officer working with the British North African forces in April 1943:

" During a recent series of 180 cases, operated on by two Field Surgical Units at a Main Dressing Station, I found that 42 were transfused before, during or after operation. I used 116 bottles of plasma, 11 bottles of fresh blood and 63 bottles of saline. These cases were mostly priority 1, and this accounts for the number and volume of transfusion. In this series only three died." The most telling comment that can be made on this is that in the last war, instead of three deaths, there might have been 42.

Most of this blood, but by no means all, comes from ordinary men and women in Great Britain. Obviously the average man and woman, more or less safely at home, would prefer that this should be so. But it should be remembered that soldiers in the field give their blood even in the midst of fighting.

Between 2nd March and 30th March, 1943, one Field Transfusion Unit operating in the forward zones of the desert received 1,776 bottles of blood from the troops in the field themselves, and still larger quantities come from the troops at the base. In all the Libyan battles, base troops in Cairo and elsewhere sent forward to the fighting zone 10,379 bottles of blood.

4 Blood Relations: The Story of the Blood Group

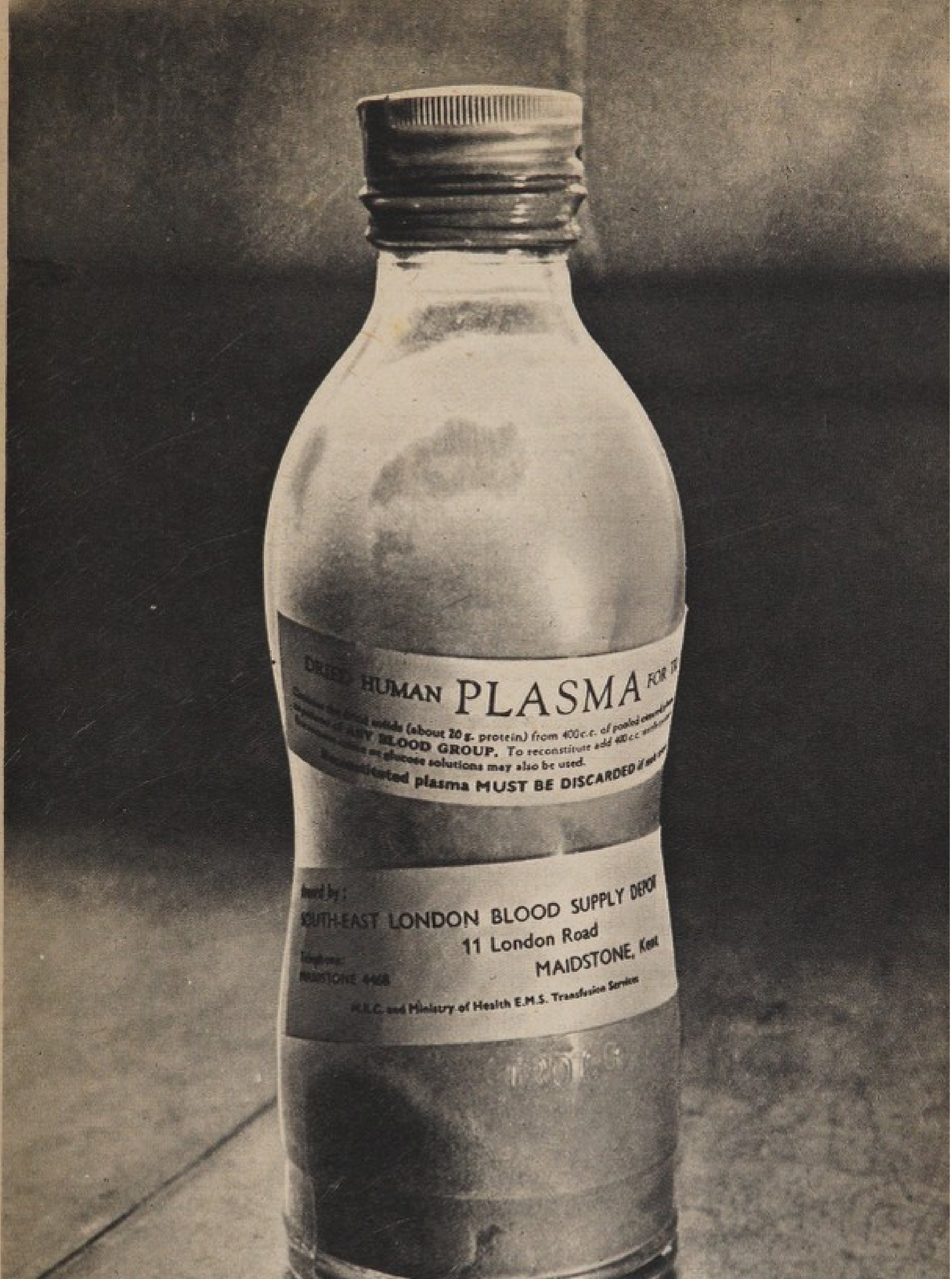
WHEN Jim and Mabel and the rest walked up the bomb-damaged steps to the Parish Room they had, you will remember, cards in their hands. An important entry on each card was a statement that the donor belonged to a certain blood group. It was with the discovery that people belonged to different groups that successful blood transfusion began to be possible.

Hundreds of years ago transfusion was tried, sometimes with animal blood, sometimes with the blood of a relative moved by love of a dying man or woman. Nearly always these blood transfusions were not only unsuccessful, but acted as if deadly poison had been poured into the victim's system. In 1900 Professor Landsteiner discovered the reason.

The red blood corpuscle is, as we have seen, a little circular disc. It is three-thousandths of an inch across, and only a quarter of this in thickness. Even then it would not be small enough to pass through the smallest capillary blood vessels if it could not bend and change its shape. Now this minute and fragile thing is really a bottle filled with a special chemical compound called hæmoglobin. It seems that Nature has invented hæmoglobin for the special purpose of picking up minute quantities of oxygen breathed into the lungs, and dropping them again in the cells of the body. If there were no hæmoglobin in the blood it would require 300 gallons of blood to carry one gallon of oxygen, and this would mean, amongst other things, that we would require a heart almost bigger than our human bodies to pump the oxygen round to all the tissues quickly enough to supply them with the minimum amount required. But thanks to the way in which hæmoglobin can take up and set down oxygen, seven gallons of blood can carry one gallon of oxygen.

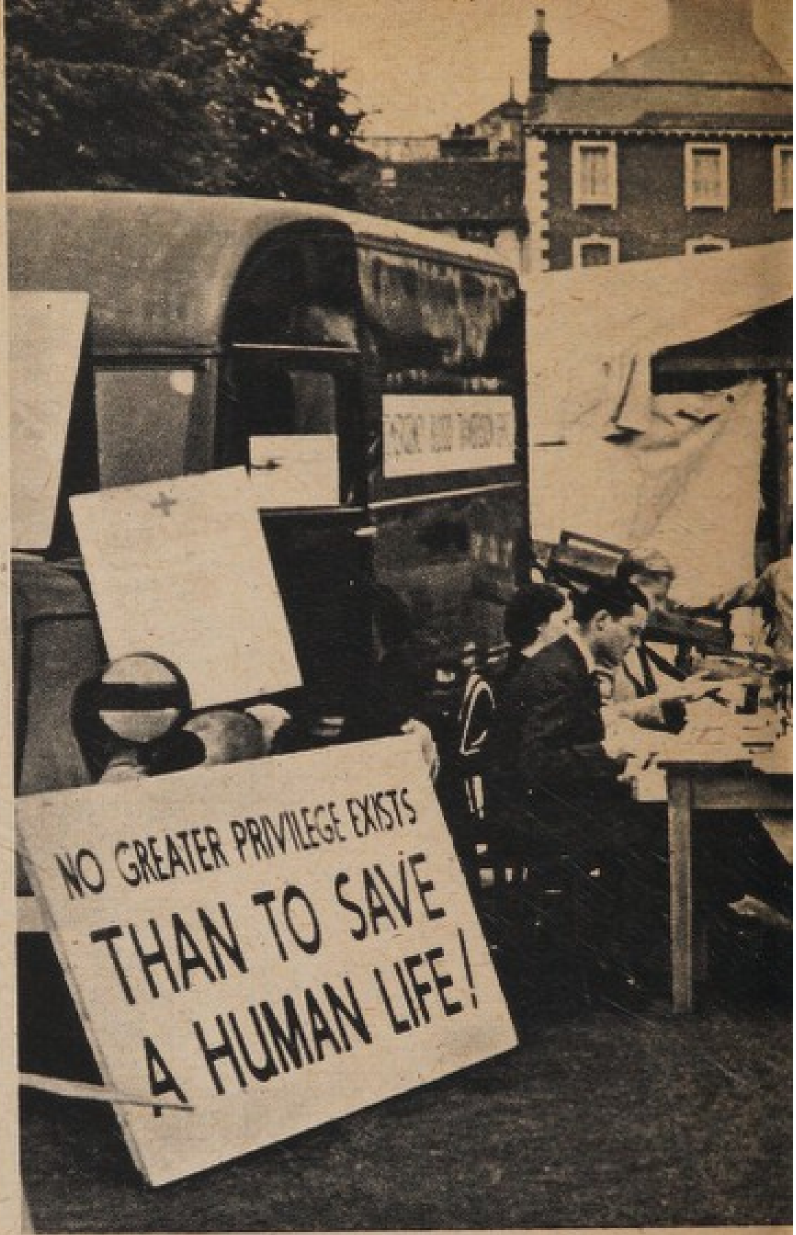
That is the task of the red corpuscles. There are about 25,000,000,000,000 of them in the average human being, and the heart and plasma transport system pump them round quickly enough to supply as much as a gallon of oxygen a minute to a man taking physical exercise.

If you take a drop of blood and mix it with several times its volume of a suitable fluid and look at it under the microscope, you will see the blood corpuscles floating about, evenly spaced, and keeping a reasonable distance from one another. If to these diluted red blood



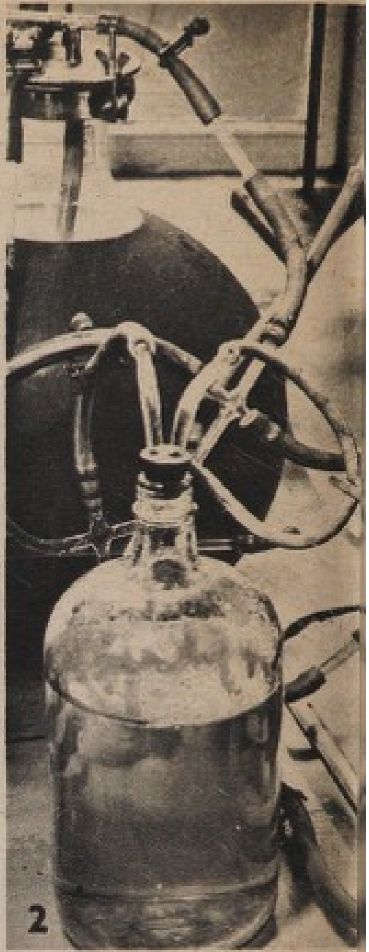
The life-saver. In the form of dried plasma, the blood donor's gift is preserved so that it can be used months later on distant battlefields.

Call for volunteers. People like these, in cities and villages all over Britain, give their blood to make the life-saving plasma.

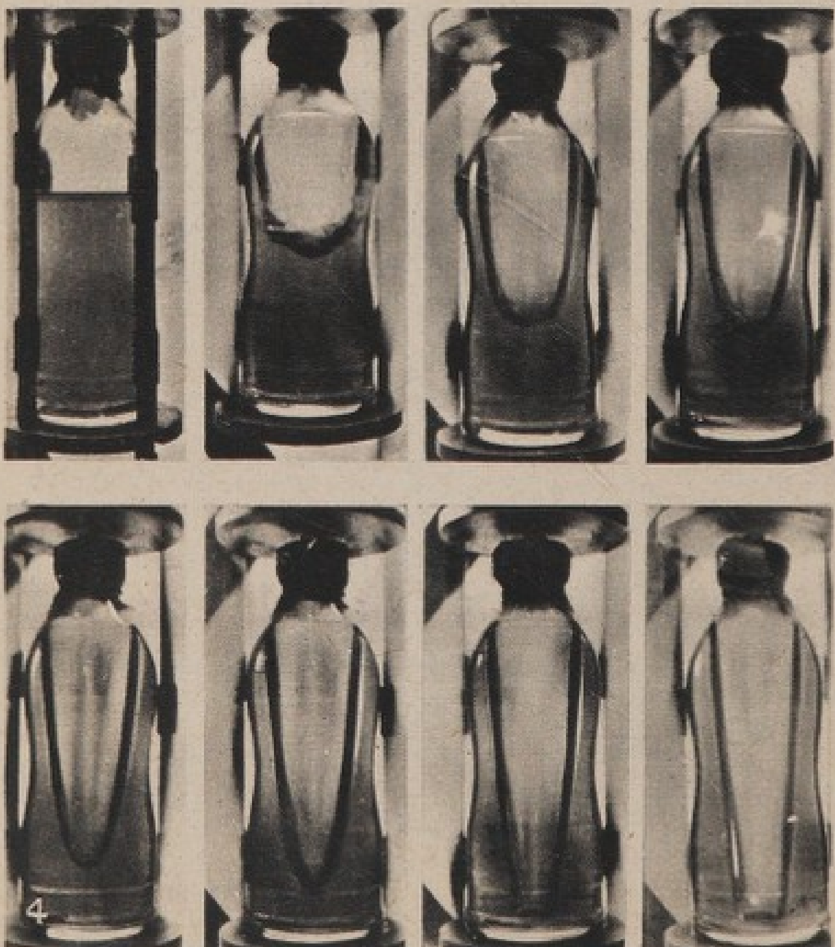


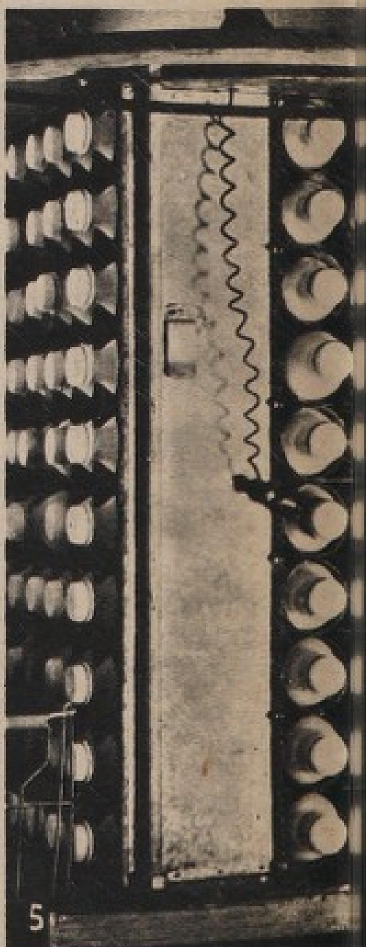
Making the gift. At a local centre a pint of blood is taken in a few minutes.

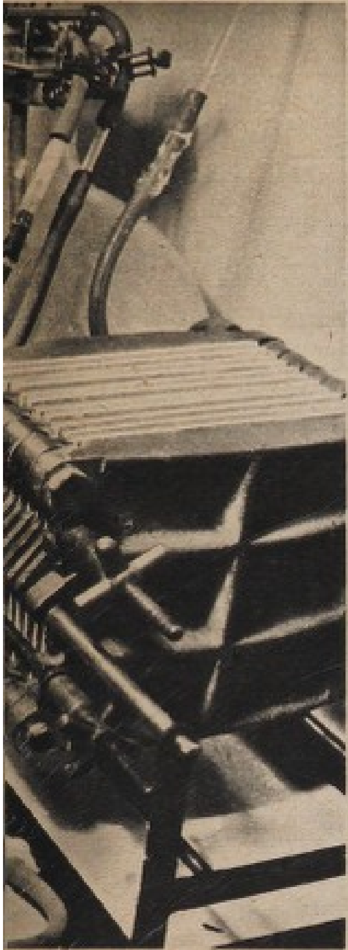
After giving blood. A short rest, a cup of tea, and a donor can be back at work.

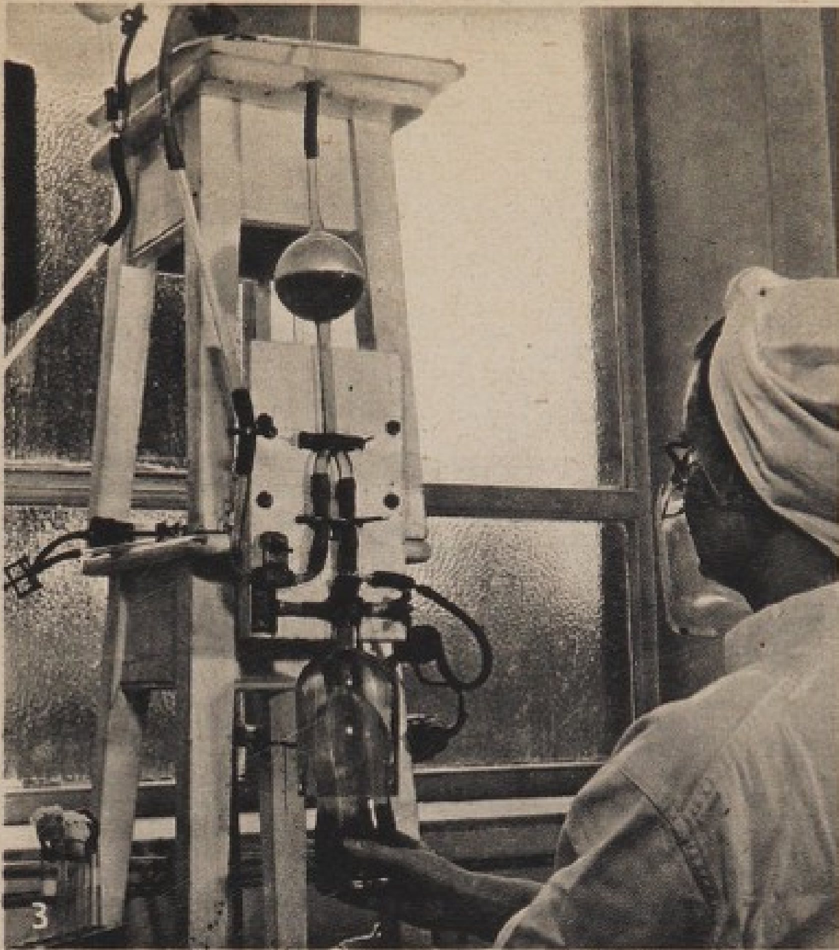


The blood you give goes through many processes (see pp. 25-30). **1.** Plasma has been siphoned into bottles containing kaolin, which prevents it clotting. **2.** At the drying centre it is filtered, to remove impurities, **3** measured off into sterilised bottles, **4** and rotated in a spin-freezing machine. (The top left-



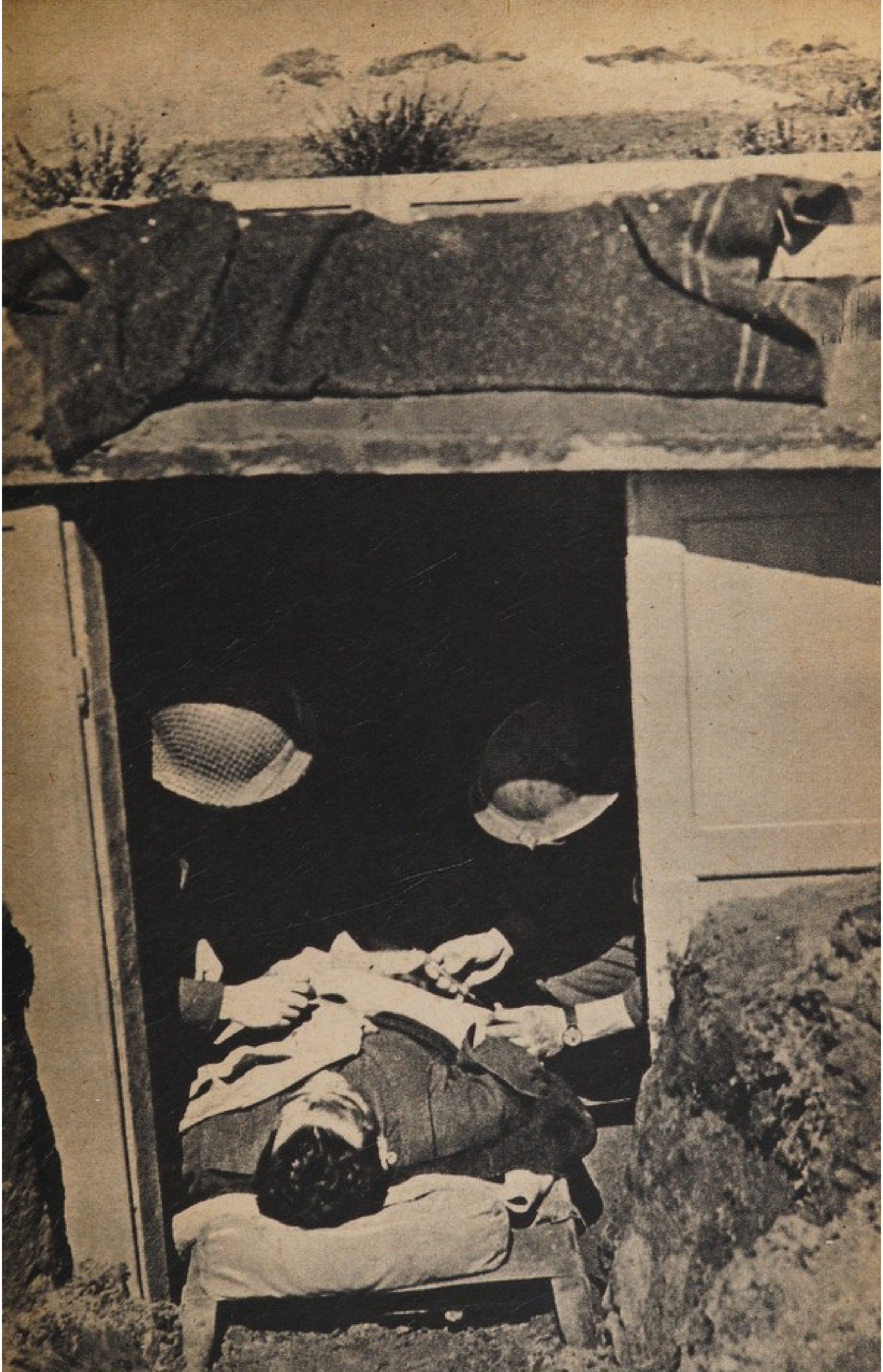




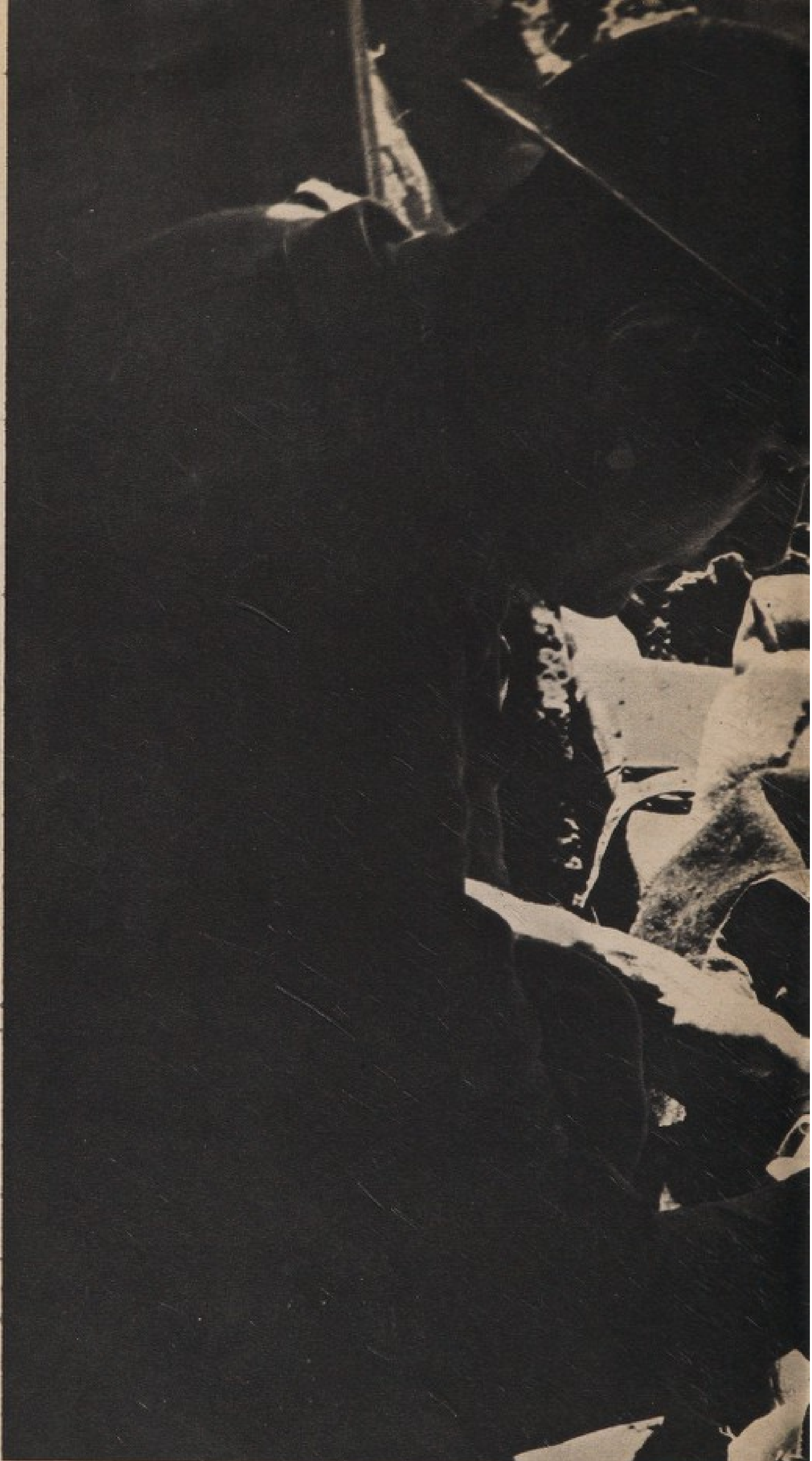


hand bottle has not yet begun to spin and the liquid is at normal level ; the bottom right-hand bottle, spinning at full speed, is throwing the liquid up against its sides.) **5.** The plasma, now frozen, is put into a vacuum drying chamber. **6.** The finished product is distributed to Transfusion Centres.

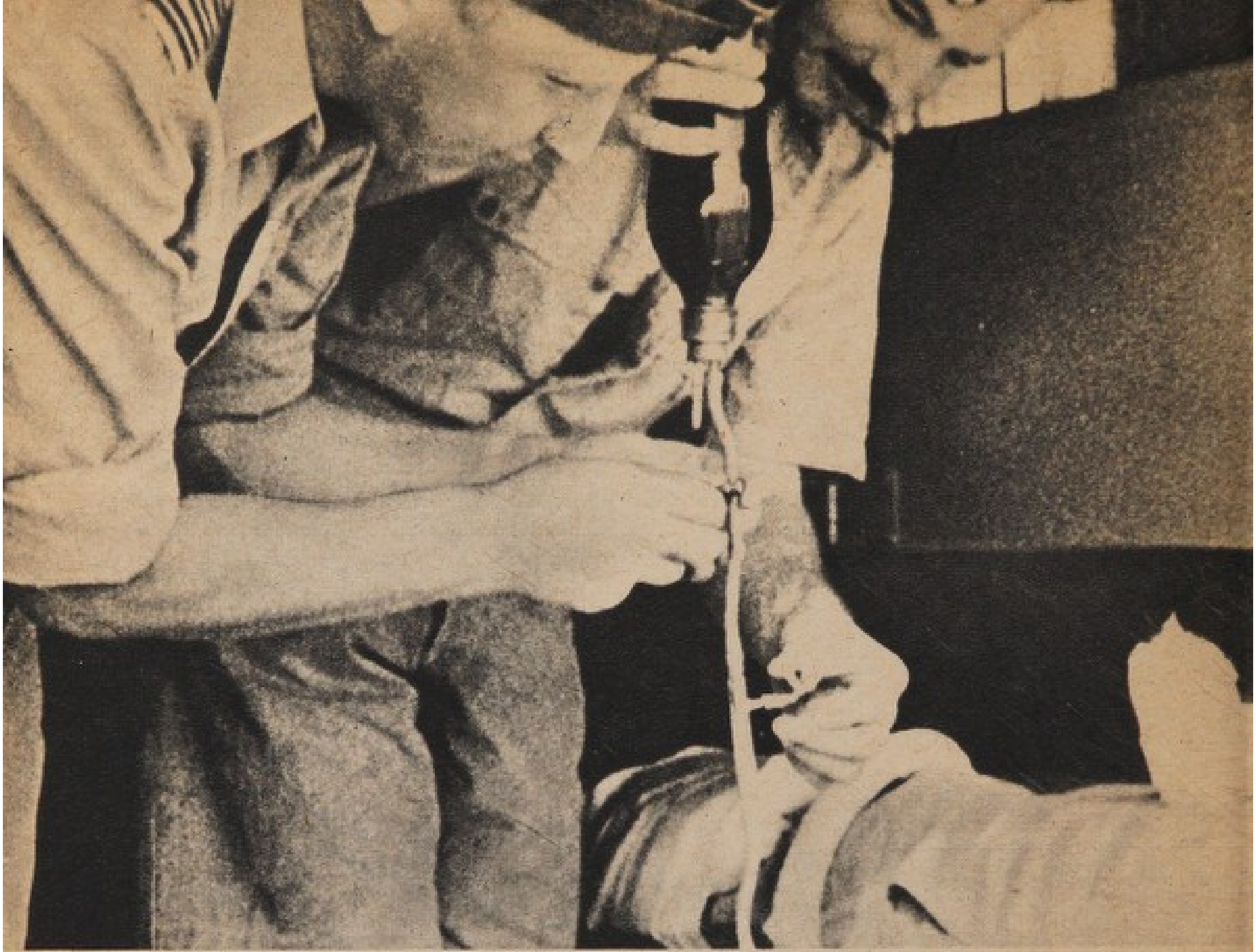
Blood group. Service men and women, as well as civilians, give their blood. (*Above*) Sailors have samples taken for " grouping." It is on correct grouping that successful transfusion of whole blood depends. (*Below*) Samples of blood being classified in an Army laboratory.



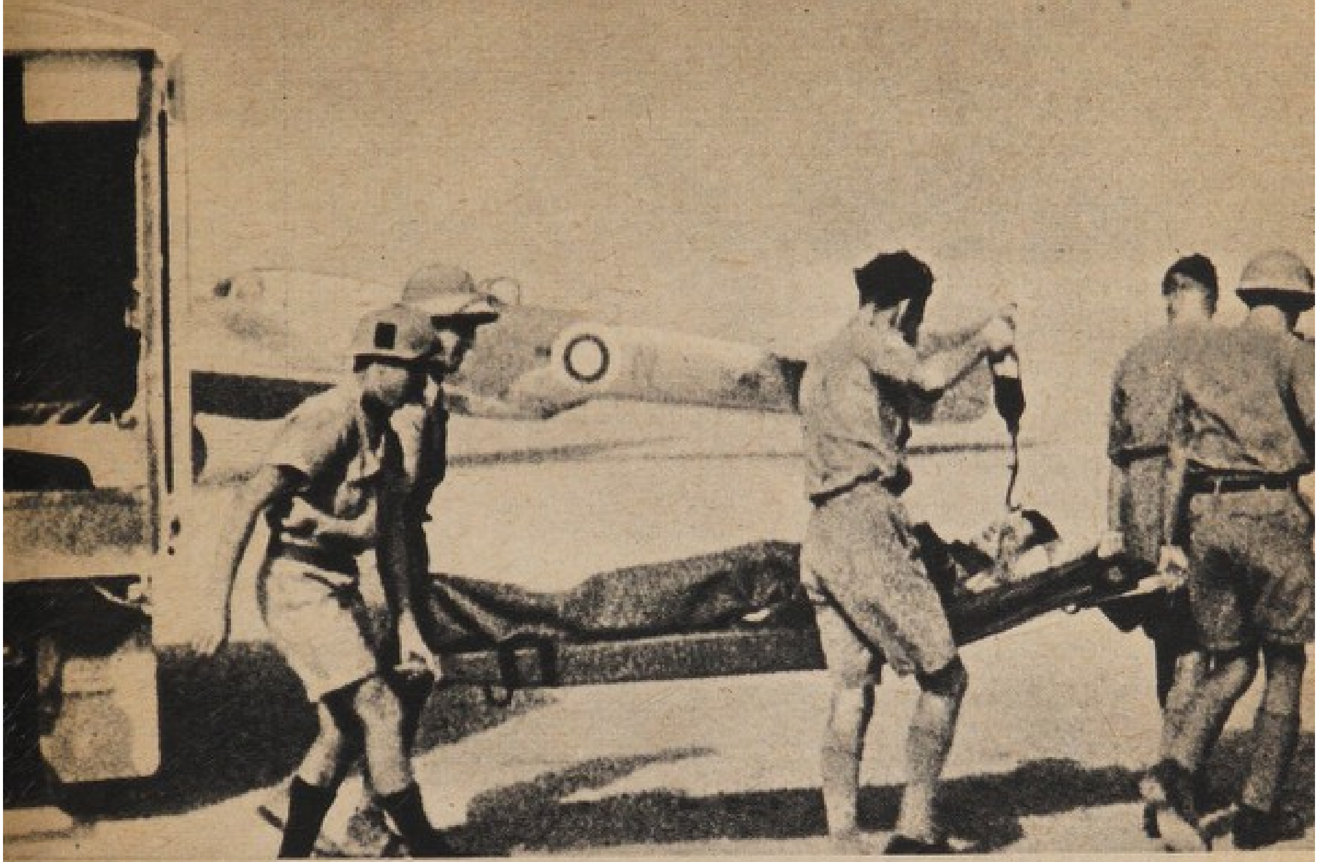
The one chance of life for many a man wounded in battle is an immediate blood transfusion. In a forward medical post on the Anzio beachhead, a casualty is given a morphia injection before the transfusion.



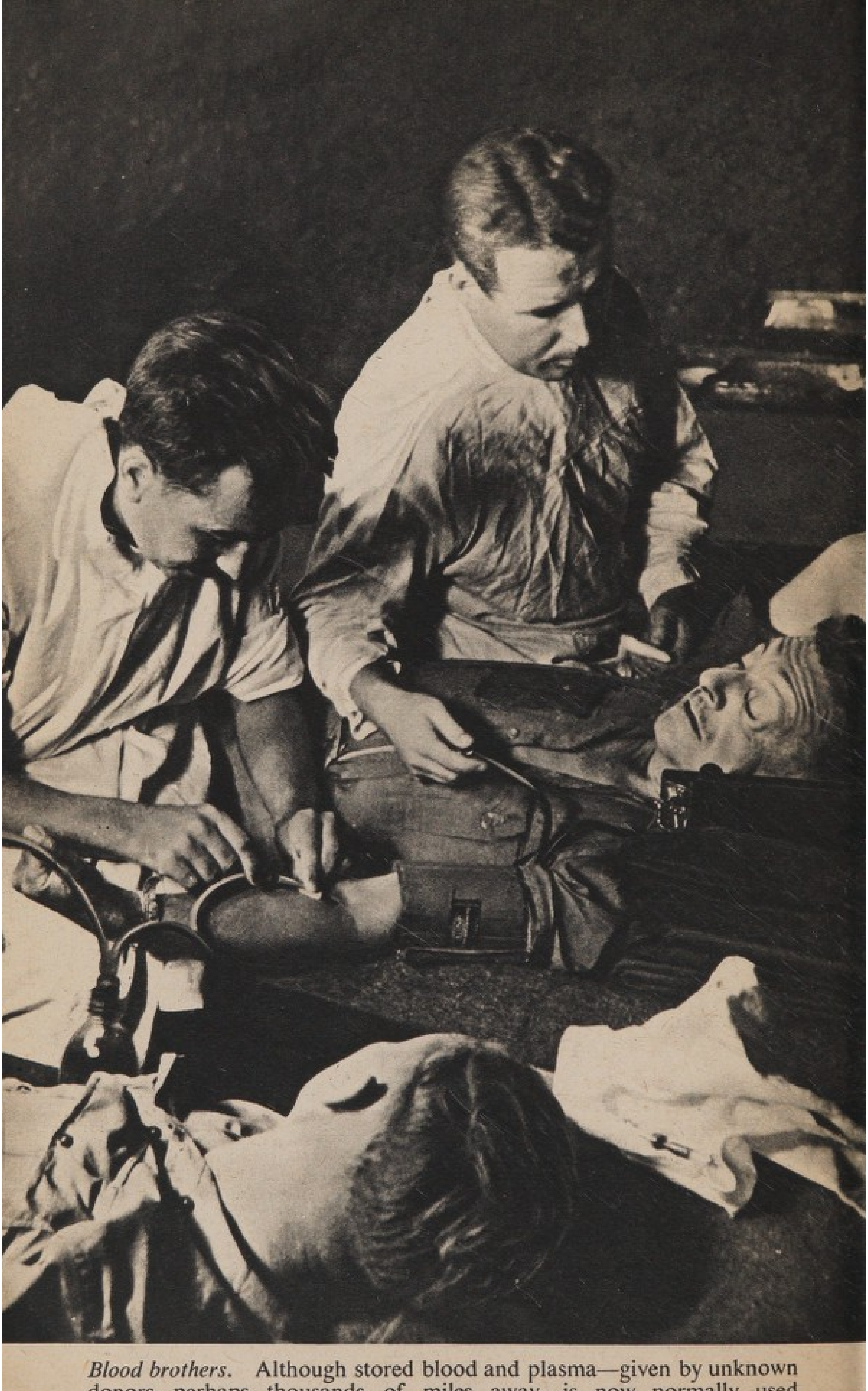
Out of the shadow. The last drop of plasma has dripped into the wounded man's arm, restoring life and strength, so that he can safely be moved to hospital for further treatment.



Non-stop transfusion. A wounded airman is being hurried to an R.A
hospital. All the time—in the ambulance, on the landing ground, as



is being lifted into the Red Cross aircraft—transfusion continues, and a
spare bottle of plasma, for use on the journey, follows him into the plane.



Blood brothers. Although stored blood and plasma—given by unknown donors, perhaps thousands of miles away—is now normally used for transfusions, in an emergency the old method of direct transfusion from one man's veins to another's is sometimes necessary.

corpuscles you add a small drop of the plasma or serum from some other human being, one of two things will happen ; either the red blood corpuscles will go on floating around exactly as before, or quite soon you will notice them clumping together in lumps—agglutinating, as it is called. When this clumping of the blood corpuscles has gone on for some time, the little bottles crush against one another so tight that they burst, the broken skins sink to the bottom of the fluid, and all the rest of the fluid becomes dyed pink, like red ink, with the hæmoglobin that has poured out of the broken bottles. This bursting of the blood cells and emptying of their contents is called hæmolysis, or blood death. It means that the value of the blood cells has been destroyed.

The reason for the *grouping* of blood donors is that we must know beforehand whether this clumping will happen when the blood of two persons is mixed together, for if clumping occurs the blood transfusion will be useless and the blood recipient will probably die. What Professor Landsteiner found was that in the red cells of most people's blood there are two passengers known only by what they do. He called these two passengers A and B. You may have in your blood cells both A and B, or only A or only B, or neither of them.

In the same way, in the fluid portion or plasma of your blood, there may be one or other or both of two passengers called anti-A and anti-B. A and anti-A cannot get on together, nor can B and anti-B ; directly they are found in the same blood stream trouble begins.

This is what is meant by saying that your blood belongs to one group or another. The following table shows how blood is grouped according to the passengers contained in the red cells and the plasma. In the first column is the name of the group, in the second column we have the passengers in the red cells, and in the third column the passengers in the plasma.

Group	*Red Cells*	*Plasma*
A	A	anti-B
B	B	anti-A
AB	A & B	Neither
O	Neither	anti-A and anti-B

You will see from this table that if you have A in your red cells you will have anti-B but not anti-A in your plasma ; if your red cells contain B, your plasma will contain anti-A, but not anti-B ; if you have both A and B in your red cells, then you will have neither anti-A nor anti-B in your plasma. If you have neither A nor B in your red cells, you will have both anti-A and anti-B in your plasma.

Whatever A and B, anti-A and anti-B are, one thing is quite certain, that there is something about anti-A which destroys any red cells containing A. As we have said, A and anti-A and B and anti-B cannot exist together in the same blood stream.

Suppose you belong to Group B and you give your blood to save the life of a wounded man. And suppose the wounded man belongs to Group A. When your blood is mixed, the anti-B in *his* plasma will kill your blood cells and no good will come of the transfusion. If you were able to see under the microscope some of your blood after it had passed into his veins you would see the blood cells clumping together in heaps.

If, on the other hand, your blood belongs to Group O, that is to say, has neither A nor B passengers in the cells, it does not matter so much to what group the wounded man belongs ; whatever anti-A or anti-B there may be in his plasma will not be able to destroy your blood cells, because they contain no A or B.

Probably you will be wanting to ask a question at this point. Why, you are wondering, will not the anti-A and anti-B contained in the plasma of anyone belonging to the O group not destroy the recipient's blood cells if they have got either A or B in them ? The answer is, that although a certain amount of damage may be done, the donor's plasma will be dripped little by little into the recipient's blood stream, and so will be too diluted to do any serious or immediate damage.

That is why people belonging to Group O are sometimes called universal donors ; because their blood can, with more or less safety, be used to transfuse anybody, whatever the group to which he belongs. In an emergency, blood of this group can be used without testing to find the blood group of the wounded man.

However, this is only safe to a certain degree, because although the blood cells of a Group O " universal donor " will not be killed, the anti-A or anti-B in its plasma might kill a dangerous number of the recipient's cells if they contained A or B.

In a few cases, indeed, this does happen because in some individuals of the O Group the plasma is particularly strong in anti-A or anti-B, and then serious damage may result. For this reason, although people in Group O are called universal donors, and although their blood can, in case of necessity, be used for any patient, doctors prefer, whenever there is time, to make a direct matching of the blood of the donor and of the recipient in every case. That is to say, they take a drop of plasma from each blood and mix it with the red cells of the other blood. If the patient's plasma does not agglutinate the donor's red cells, nor the donor's plasma the patient's red cells, the two bloods are compatible.

It has, of course, taken much time and practice before doctors could know exactly the best way of transfusing blood to avoid all the dangers, and one of the blessings of the Blood Transfusion Services which will last long after this war is over is that they have given doctors the opportunity to learn in a short time what might otherwise have taken a generation.

So much for the meaning of blood groups. It is most important to realise that the existence of these groups does not mean that anybody's blood is better or worse than anyone else's, except for the one purpose of mixing with the blood of a given recipient.

Blood as Individual as a Finger-print ?

When Professor Landsteiner first discovered the existence of groups, and therefore the reason why blood of incompatible groups must not be mixed, he thought there were just three such groups ; the fourth, the AB group, which is much rarer, was added to these three later.

As so often happens, further research has made the problem very much more complicated, because it is now known that there are sub-groups—that is to say, each of the four chief groups can be divided into more than one group. Indeed, it looks as if some day we shall find that almost every individual has blood which is different from the blood of any other individual on the face of the globe, and that we shall be able to identify an individual from a drop of his blood in the same way as we can from a finger-print.

In 1940, it was discovered by Landsteiner and Wiener that the blood of certain people contains a passenger known as the Rh factor. Such persons are known as Rh positive, whilst the minority of people who lack this factor are known as Rh negative. When an Rh negative woman has a baby by an Rh positive father, the child is liable to develop a form of anæmia which may be fatal. Transfusion with Rh negative blood is required to save the life of the baby and, should the mother need a transfusion, it is essential that only Rh negative blood be used. Special banks of Rh negative blood are now kept for this purpose.

There is one other thing which has to be carefully checked when a donor's blood is tested and grouped. It is, as we have seen, nonsense to imagine that such things as character, strength and mental attitude can be affected by a blood transfusion, but there are a small number of diseases which could be transmitted from donor to recipient if the greatest care were not taken to prevent it.

The most important disease that could thus be transmitted is syphilis, and all necessary tests are made on donors' blood to guard against this. There is, in fact, only a very small number of such hidden infections. Any information of this sort is kept absolutely secret, and used only for the safety of the persons directly concerned.

There are one or two other diseases that have to be watched for, including malaria, measles and influenza : that is why questions about the recent health of the donor are always asked before blood is taken.

5 How Blood is Given

NOW that we know what blood is, why it is needed, how it is used and what is meant by a blood group, let us follow the gift of blood from the moment when it is taken to the moment when it is used to save life.

We left Jim and Mabel, Corporal Evans and Mrs. Alice Edwards waiting their turn to go behind the low screen where four beds were ready for them. The Blood Transfusion Services do not, of course, consist only of givers and receivers. At every stage well-trained, conscientious men and women have to carry out difficult work in a way which will make mistakes impossible. Carelessness at any stage of the process would cost the lives we are trying to save. Everything is rehearsed again and again—that is why no accidents occur during the process of taking blood from the donor. No time must be wasted, and the trained team of workers have practised together until they know exactly how to bleed the largest number of donors in the quickest and safest way.

Of course, the arrangements differ from place to place and from time to time, but here are the details of the team waiting on this Thursday afternoon for those who have come to give their blood. It consists of eight people—one Medical Officer, four nurses, one orderly and two drivers. In this team the Medical Officer is a man ; frequently, like other members of the team, the Medical Officer is a woman.

Now the drivers are not just drivers. They do not sit in their cars waiting for things to be done inside, until they can drive off again. One of them acts as receptionist. She has already asked Jim and Mrs. Edwards and the rest if they have been ill lately. She has checked their cards to see that no mistake has been made in name, address and other particulars. Just before their turn comes she has seen that they have their arms bared to well above the elbow, and now she takes them to their beds.

The other driver is looking after the donors who have already been bled. She sees that they rest for 15 minutes, and gives them a cup of tea. After that, the Medical Officer inspects each arm while this driver stands ready with a small strip of elastic dressing to put over the prick-mark and, very often, a packet of iron tablets to be taken by each donor during the next week.

The donors lie down. Their arms are cleaned with antiseptic. The Medical Officer gives each a local anæsthetic (Jim says he doesn't want this, as he doesn't mind the prick of a needle). The needle is carefully pushed into a vein—a skilled job, since the vein may be quite invisible, and the point of the needle must rest precisely within its slender walls, or the vein will be buttonholed or pierced and no blood will enter the bottle.

It is worth while looking at that needle. It was made in a British factory, though before the war we were dependent upon the Germans for most needles. The process of the needle's manufacture is remarkable. It began by being a piece of steel tubing. The steel tubing was drawn out longer and longer, becoming smaller and smaller in diameter in the process. By the time the tubing had become small enough in diameter it was long enough to be divided into hundreds of thousands of needles. The whole process, carried through without the application of heat—the cold-drawn process, as it is called—is so skilfully done that only one needle in a million breaks. Next the needle has to be sharpened by a highly skilled technician. In one Transfusion Centre, eight men and women spend the whole of their working time sharpening needles.

The Blood Must Not Clot

Before describing what takes place when the needle is inserted in the donor's arm, it is necessary to explain that successful transfusion on a large scale became possible only after the discovery that chemicals could prevent clotting of blood. All healthy blood clots. We all know this from experience. If we prick a finger or cut ourselves when shaving, it will not be long before the drops of blood oozing out cease to run and become sticky and almost tough. It is Nature's way of closing a wound. Until this discovery was made transfusions were usually *direct* transfusions from the donor to the patient. The donor lay side by side with the patient, and the blood was dripped through a tube. There was no interval during which the blood could clot. Storage of blood—and consequently its large-scale use—became practicable only when anti-coagulant chemicals came into use.

Note what happens now when blood is taken from a donor. The needle goes into the vein of the arm. The other end of the needle has been attached to rubber tubing, which leads into a glass bottle. In the bottle is the chemical which prevents clotting. Once the needle is in the vein the blood will flow slowly and steadily into the bottle, which must be kept shaking all the time to produce a uniform mixture with the chemical. Sometimes the nurse shakes the bottle herself. Sometimes an automatic shaker (looking rather like a gramophone turntable) is put on the floor by the bed and conveniently does the job for the nurse.

At one centre in Scotland another method of mixing the blood with the anti-clot chemical is adopted. The bottle of chemical is hung high up, and drips by gravity into the tube along which the blood is flowing from the donor's vein ; thus blood and chemical are kept mixing all the time.

When about a pint of blood has flowed out of the vein, the needle is removed. A pad is put on to the arm over the punctured vein and the donor walks across the room to a couch and rests.

If you have given your blood and watched others giving theirs, you will know that very few donors suffer any uncomfortable feeling. Medical men will assure you that there is nothing in the least heroic about giving blood. Yet for ordinary men and women, it *does* require courage to give blood for the first time. They do not know just what to expect : they go prepared to suffer some pain or discomfort because they know that their gift may save a life.

In fact, the number of people who feel faint after giving their pint of blood is less than one in twenty. Indeed, more people feel the better for their bleeding than feel faint for a minute or two at the time. If for some reason the nurses feel that the donor is suffering inconvenience, the flow of blood is stopped at once and the donor waits until another day before completing his gift. Great care is always taken to rest donors before they leave. They lie on a couch for fifteen minutes or so, drink a cup of tea and eat a biscuit, and then they are ready to return to their work. In every case the donor's red bone marrow and the other blood-making organs of his body make up the loss within a very short time.

When the last donor has been bled, the collecting unit packs up its equipment and takes the blood off to the depot to undergo necessary treatment. As far as Jim and Mabel and the rest are concerned the whole thing is over. But what happens now to the blood they have given ? Let us take a look at what goes on behind the scenes.

6 The Secret of Plasma

NEITHER the donors nor the recipients see the complicated processes and all the careful work that make the vital blood gift possible.

To begin with, cleanliness is absolutely essential. In one centre alone there are 3,500 bottles, 4,000 pieces of rubber tubing and 6,000 pieces of glass tubing to be washed every day, and 2,000 needles to be sharpened every day. Then think of the care that must go to packing and transportation. The main Drying Centre alone receives every week the equivalent of 2,500 bottles of plasma from the London and Regional Depots and the Navy, and sends out weekly a similar quantity of the dried products to the Services and to civilian centres.

The Gift is Treated with Skill

Most amazing of all, perhaps, is the combination of scientific discovery, efficient organisation and trained service that makes possible the conversion of blood into forms that will preserve its value far away from where it was given, and long afterwards.

The blood collected on that Thursday afternoon was put into a refrigerator and brought down to a temperature of about 2° C. within an hour. It must not be allowed to freeze because that would destroy the blood cells, but it has to be brought to the lowest possible temperature short of freezing to delay, so far as is possible, the decomposition which begins in blood from the moment it is shed.

Thus, the whole blood, cells and all, is kept in a Blood Bank ready for emergency. It will not be kept for more than twenty-one days at most. That is regarded as the extreme limit, after which the blood cells are not suitable to use. But only the *cells*. The fluid they float in, the plasma, is still useful. In fact, one of the things the war has taught us is that plasma, after the cells have been removed, is by far the most practical blood substitute. For plasma does not spoil as quickly as whole blood and —we shall see how this is done—can even be made to keep indefinitely. So, under battle conditions, far from the home base, most blood transfusion is plasma transfusion and not whole-blood transfusion.

That, by the way, is the answer to a question blood donors very often ask. " Why," they say, " can't we know the actual soldier or sailor to whom our blood gift goes ? " If the donor's whole blood were used for a transfusion, it would be possible for the donor and the recipient to know one another. In Russia the bottles of whole blood are all marked with the donor's name, and the recipient, if he wants to, can be told whose blood has been given him, and can meet and thank the person who helped to save his life. But when blood transfusion takes the form of transfusing the plasma alone, this is not possible, for the plasma of many donors has to be pooled.

This has to be done to make quite sure that the occasional specimen of plasma very strong in anti-A and anti-B passengers, which by itself might be dangerous, is rendered harmless.

It takes about two-and-a-quarter pints of blood to produce one pint of plasma, so that for every wounded man who has received a pint of plasma the gifts of three people have to be used. This plasma which he receives can be in two forms. It can be either liquid plasma

—what is left of the blood-gift when the red cells are removed—or it can be liquid plasma which has been dried, then " reconstituted " with distilled water, when it is needed, just like dried egg or milk.

Plasma Made to Keep For Ever

Dried plasma will, as far as we know, keep for ever, but it must be dried in a special way if its delicate life-saving powers are to be preserved. Scientists have learnt how to do this only since the beginning of this war. Plasma contains a number of highly complicated substances called proteins, the basis of all living matter. It is by the constant changing of these proteins, their building up and breaking down, that the body exists. In plasma taken from the living body, the breaking down goes on without any building up to make good the loss. If plasma is to be kept, these changes, and all other ways of decay, must be arrested. They take place in the presence of warmth, and moisture even in minute amounts. Freezing the liquid plasma prevents the changes which are bound to go on as long as moisture is still present. Drying it, extracting every particle of moisture from it, stops the changes altogether. But this drying must be done without heat—later we shall see how.

Suppose, then, the blood gift is to be turned into dried plasma for transport and use months, even years hence, perhaps in some far country. This is what happens to it.

First, having been brought from wherever it was given—the Parish Room that Thursday afternoon, for example—to the Regional Depot, it is stood in a cold room and the blood cells are allowed to settle to the bottom, which they do because they are heavier than the plasma in which they are bathed. Soon the contents of the bottle separate into two layers ; a dull red layer of cells at the bottom and a cloudy yellowish layer of plasma at the top. Next the plasma is siphoned out into large bottles containing a substance called kaolin, which removes the clotting factor and thus allows the plasma to be filtered easily. Into these large bottles goes the plasma from several blood-gifts.

Vigilance at Every Stage

Now that the blood cells have been removed, the plasma can be brought right down to freezing point, the best temperature for preserving its proteins. In this frozen state it leaves the Regional Depot and is taken to one of the drying centres.

At the drying centre it is thawed out and a sample taken and examined to see if it contains any bacteria. So careful is the treatment given at the Regional Depots and throughout the process that only very occasionally is trouble discovered. Here and there a bottle top gets unstuck or an unaccountable cloud or speck appears, but only a small amount of the total blood-gift has to be discarded as useless and dangerous. When you think how hard it is to keep anything perfectly sterile, you realise that this result is possible because all the workers in the Blood Transfusion Services, down to the least bottle washer, feel that the material with which they are dealing is precious. A moment's carelessness in cleaning a rubber tube might mean the waste of several donors' life blood. A single speck of dust may be disastrous. Thanks to this sense of responsibility which is shown at all stages, accidents are very rare.

When the sterility, the perfect cleanliness, has been proved, there is a final filtration through asbestos pads. Then the plasma is poured into smaller bottles, in a carefully measured amount, by women working in a sterile room and wearing masks to prevent their breath from spreading germs. These bottles have just come out of an autoclave, a large container into which high-pressure steam is passed to sterilise every bottle inside and out.

The two women who received the bottles containing Mabel's and Jim's and Mrs. Edwards's contribution were in civilian life a milliner and a ballet dancer. Now they have been trained to prepare this precious fluid in a way which will make certain that not one speck of dirt can pass their scrutiny and bring not life but death to some wounded man or woman.

When each bottle has been filled with an exact amount of plasma it is closed with a filter cap of gauze and cotton wool which lets air pass in and out. Water vapour can pass through also, but no dust or bacteria can pass in. The reason for this will be seen in a moment.

The bottles are now taken into a large refrigeration room and placed in a machine which spins them round and round. This flings the plasma up against the side of the bottles, leaving a hole in the middle, just like the hole in the water when the bath is running out. In this position it freezes, thus exposing a larger surface from which the drying can take place. This spin-freezing, as it is called, speeds up the process of drying once it begins.

The hole in the middle is biggest at the top and if exactly the right amount of plasma has been poured in there will be a hole at the bottom of the bottle rather smaller than a threepenny bit. If you do not see this hole you know that too much plasma was put in by mistake and that will mean too long a time taken in drying ; so the bottle which shows plasma at the bottom without a round empty space must be re-processed.

Drying Without Destruction : The Scientist's Problem

The moment has now come for the drying—by far the most interesting part of the process, but one which it is rather hard to understand. It is a most difficult process. It cannot be done by just boiling or heating the plasma in the ordinary way, for that would destroy it.

It would have somewhat the same effect on the plasma as boiling has on the white of an egg.

Think of a saucepan of water on a hot fire. That water is made up of tiny pieces called molecules and every molecule in the water (and in everything else for that matter) is in a state of continuous movement. No molecule gets very far, however, since it is for ever knocking against the neighbouring molecules. The hotter a thing becomes the more the molecules move, until eventually the top surface of molecules in the water move so violently that they escape into the air above. That is what is meant by boiling. Water boils when its molecules escape in the form of steam into the air above. Now the air also consists of molecules in motion, and quite a large number of the water molecules hit against the air molecules and bounce back again into the water. The more air molecules there are, the higher the temperature has to be raised before the water will boil. By removing nearly all the air molecules the water can be made to " boil " at such a low temperature that it remains frozen throughout the whole process.

That is the secret of drying plasma. In ordinary air at normal atmospheric pressure the heat required for boiling would destroy the plasma before it dried it. Therefore the drying is carried out in a high vacuum so complete that the plasma remains frozen throughout. At this temperature the delicate proteins of which plasma is composed are not damaged, so that they will continue to serve their vital functions when water is added to the dried product, maybe years later.

The bottles are placed in containers, the containers sealed up, and the air is pumped out of the containers and so out of the bottles inside. Each bottle fits into a round tin which can be heated by electricity. At the bottom of the containers are refrigerator coils made cold exactly as they are in an ordinary domestic refrigerator. The heat makes the water molecules in the frozen plasma dance violently until they dance right through the bottle cap and, having no air molecules to oppose them, they fly to the cold coils and there turn to ice.

The Last Drop of Moisture Goes

Thus, bit by bit, the moisture is expelled from the plasma until there is so little left that without careful tests you would think that the plasma was absolutely dry. This is not so, however. Even after it has been in the vacuum containers for three days there is still a two-thousand-five-hundredth part of the original water left. That is hardly enough to notice, but quite enough to spoil the plasma ; quite enough to allow some of the proteins to carry on their natural changes. This last little remainder of dampness must be eliminated by a second drying.

First, fresh caps are put on to the bottles. These consist of rubber covers screwed into position by metal rings. A hypodermic needle is inserted into each cover. Then the bottles are placed in another container, at the bottom of which are saucers of a white powder—phosphorus pentoxide—a chemical which absorbs any moisture brought near it. Again the air is pumped out of the sealed containers and the bottles inside, and the phosphorus pentoxide sucks out the last trace of moisture in the plasma through the hypodermic needles. After two days, the plasma is totally dry. Then, pure dry nitrogen is introduced into the containers and passes into the bottles. (Dry nitrogen is used and not dry air because nitrogen has no injurious effect on the plasma, whereas the oxygen in air might turn the fats in the plasma rancid.) The bottles are taken out of the containers and the needles quickly withdrawn from the caps—the tiny punctures they have made in the rubber covers close themselves before air has a chance to get in. The cap is finally sealed. The dried plasma—it looks like a mass of yellowish white crystals—is now safely preserved.

If you were to visit a great drying centre you would see a room full of closed cylinders, you would hear a low hum of a motor, you would notice a control panel with warning lights ready to flash on if any of the hidden processes should go wrong. That is all you would see; but screened from your eyes there is the blood-gift of over 7,000 donors being turned from a highly perishable substance into a lasting saver of lives.

7 The Gift Works Miracles

WHEN the first wave of troops landed in Normandy, the gifts of 10,000 donors went with them. Before that, in Italy, Sicily, North Africa, Greece, Crete and Burma, blood gifts saved many men. Blood from Britain was dropped by parachute over Malta in the direst days of the siege. At almost every hour of the day and night, all over the world, on the battlefield, on the sea, on airfields, in the bombed cities of Britain, in civilian hospitals and maternity wards, the blood gift has saved the lives of men, women and children for whom a few years ago there would not have been the slightest hope. . . .

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It is 3 a.m. on a winter night. There has been silence for half an hour. Before then for perhaps forty minutes the familiar roar of returning bombers has filled the East Anglian air. We all know that sound nowadays—a rather tired sound compared with the full-throated eager roar of those bombers a few hours earlier as they passed over on their outward journey. Civilians turning over in bed hope that as many are coming back as went.

The last one has reached its airfield. No, not the last one, for once more the silence is broken. A limping sound. A great Halifax hobbling home, its fuselage riddled, its crew exhausted and some of them dead.

The Halifax touched ground at last on a field in Norfolk. Not a perfect landing by any means ; and no wonder ! The rear-gunner is dead. The navigator is dead. The pilot with one arm shot away and a wound torn in his side has pancaked down in a dream, a weary dream, for he has no strength left except in his indomitable will.

They rush him to the nearest medical post. The surgeon looks at him ; " pretty nearly bloodless " he mutters. A few years ago death would have been certain. Now they fit up a blood transfusion set and drip the plasma into his body. Soon the pilot opens his eyes. Within a few months he is ready to work again. . . .

In a stretch of the cold grey North Atlantic puffs of smoke are rising from funnels. Through the waves comes the sea-wolf's claw, a U-boat torpedo rending, with surprisingly little noise, a surprisingly large hole in a tanker's side. Fire sweeps through the ship and the crew bundle into the boats. Through the hole in the ship's side pour hundreds of tons of petrol which bursts into flames as it spreads over the surface of the water. The men, straining at the oars, are seared and scorched by the flames.

A cutter races up from one of the other ships in the convoy. The men are helped aboard, and presently blood plasma is dripping into their veins, staving off shock, making possible the long weeks of skilful nursing which will lead to recovery. Plastic surgeons mould a new face here, skin is grafted on this limb ; and a few months later these men of the Merchant Navy are out on the Atlantic once more bringing in the food and weapons of war. . . .

It is ten o'clock on a summer night in London. The roar of a flying bomb stops: and the bomb falls on a row of small houses filled with people getting ready to go to shelter. Within a few minutes the ambulances begin to arrive at the hospital. In the Reception Room a doctor quickly sorts out the casualties. Those with severe shock he sends to the Resuscitation Ward, where the beds have oxgyen laid on and are fitted with electric cradles. Soon almost every bed has a bottle of whole blood or plasma hanging above it. Under the piles of blankets, as the blood drips into their veins, the patients begin to revive.

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In wartime, our main duty lies with the casualties in the front line. But there are many other people who owe their lives to blood transfusion, mothers who could not have given birth to children, children who would not have seen the light of day, munition workers, miners, useful citizens in all walks of life.

If Jim and Mabel and Mrs. Edwards and the A.R.P. man with the limp and Corporal Evans and Harry the railwayman could have been present when a small group of ten men and women gathered together one Tuesday morning in a hospital board room, they would have seen the fruits of their small, personal sacrifice.

It was a dark, old-fashioned, gloomy room, with whiskered and bearded Victorians, the fierce-looking philanthropists of their day, frowning down from their gilded frames at a mahogany table and a worn carpet. The ten men and women had come to describe what had happened to them. Each of them would have been dead were it not for the prompt help afforded by people like Mabel and Jim. Not unnaturally, they were all proud of having been saved from death. Not unnaturally, too, they one and all wondered what sort of people they were whose blood had kept the life from seeping away once and for all from their limbs.

Factory Explosion

The first three arrived together—Mary Smith, a woman of 45, Bert Hill, aged 37, and Tom Douglas, aged 23. Those three had been working together in a munitions factory. Two others who were with them when the explosion took place were killed instantly. What an explosion does to a human body can never be pleasant reading, but it is worth while, because of the sequel, to catalogue the injuries which were recorded on the case sheets when, more dead than alive, those three reached the hospital late that night.

Imagine yourself there as they hurried the three victims from the blacked-out street into the warm casualty ward. Take a look at Bert Hill, as he lies on the stretcher. His left foot is crushed, his left leg deeply lacerated, his left thigh and right leg badly torn. There is only one thing that can possibly save him. Without it he could not stand the necessary operation—for the surgeon has seen at once that Bert Hill must have both his legs amputated through the thighs.

Next to him lies Tom Douglas. His left popliteal artery (the main artery behind the knee joint) is torn in long shreds. The muscles of his calf are also torn. His right tibia and fibula are smashed and sticking through his skin. His right leg must be amputated at the knee, and his left leg above the knee.

In the women's ward lies Mary Smith, with the blood pouring out of wounds in her head, her face, her hand, and with her left leg pulped and crushed. She, too, must lose that leg, from the middle of the thigh. . . .

That was two years ago. Now the three have walked into the room together.

None of those three had received an injury to a vital organ. If they had died it would have been from shock—from the loss of blood, and especially of blood plasma—bringing their hearts to a standstill. Now they are walking. Another triumph of modern surgery has made that possible, namely the astonishing steel movable limbs which, during their rehabilitation, were fitted to their stumps.

Bert and Tom have come from their work to the interview, for those crushed wrecks that had lain on stretchers with the life draining out of them two years before are now fit, useful members of society, trained as skilled engineers and carrying on in the very factory where the explosion had taken place. It took the blood of thirty-seven donors to perform this miracle.

Street Accident

The next person to enter the room was a cheerful young woman of 74—a wonder of a woman. This is what happened to her when she was run over by a motor bus. Her left leg was fractured, the muscles of her calf torn in shreds, her thigh-bone fractured and her knee joint pulped. She was almost dead as she lay in the hospital operating theatre, but she was immediately transfused with a pint of blood plasma and two pints of fresh blood taken from donors who came running to the hospital. Her left leg was amputated through the thigh. The artery behind the right knee was severed also, and so another pint of blood and another pint of plasma were dripped in while she was still in the operating theatre.

During the night they dripped in three more pints of blood and two more pints of plasma. During the next week gangrene developed in the injuries on the right leg, and ten days after, that leg, too, had to be amputated. Another pint of fresh blood was given. Quite soon after that, the old lady began to sit up in bed and take notice ; and now she looks like enjoying a peaceful old age, thanks to gifts of blood from nineteen different people.

The next comer, Fred Harvey, was a commercial traveller. He had not met with an accident. He had nearly died of a gastric ulcer. When he had been carried to the hospital his internal bleeding had led to almost total collapse. Nothing could have been done to save him but for the blood of four donors, and now he was on top of the world again, able to eat anything, and eager to " sell " blood transfusion to the world.

Now came an air raid casualty, James Barclay. He had been on duty as an air raid warden when an incendiary bomb struck him full in the back of his thigh and knee, tearing away the fleshy parts and burning him severely. With the raid still at its height, his leg had been amputated that night; the blood from five donors had helped him through. These five pints of blood had long ago been repaid by gifts from James's fellow air raid wardens.

Malignant Disease

Next came an enormous figure of a man. The little blue scars on his forehead and his right cheek might have told you at once what he was—a miner who had spent his life working at the coal face. He was tall and stout and grey-headed, and he had come that day from the colliery. Yet that man, only a few months before, was dying of cancer. It was one of those cases which are usually thought inoperable. He was almost a skeleton. To cut away the growth would in the old days have meant the loss of too much blood, but they took the risk, and with someone else's blood dripping into him all the time they cut away the thing which was killing him.

Now, blood transfusion is emphatically no cure for cancer. But thanks to blood transfusion this man at any rate is alive and useful to-day, and from the look of him he is thoroughly glad to be working again. He, too, has to thank two or three ordinary citizens who took half an hour off one day to give some blood.

The eighth to enter the room was Gertrude White. Twenty-nine years old, she had been sick and useless most of the time, and although she was still hardly what you would call strong she could now enjoy life and do useful work. She is one of the unfortunate ones. She was born with something wrong with her red bone marrow. Her body is unable to form red blood cells in sufficient quantity to give her strength. That means that every cell in her blood is, as it were, stifled and suffocated.

The usual method of treating such cases is to give them a special kind of liver extract, but with Gertrude White this had done no good. She could only sit back and waste her life. Then it was decided to try blood transfusion. Five pints of blood had been given her at various intervals, and though her red bone marrow will never be satisfactory, she is no longer a burden to herself and other people, but a useful if delicate member of the community.

Number nine was a member of the Home Guard, incapacitated by accident but cheerful still. He had been training with a gelignite bomb, which exploded and blew off his left hand at the wrist and the top joints of the thumb, index and middle fingers of his right hand. It tore his face and his stomach wall and injured his eyes. The shock of it all would have killed him but for the gifts from six blood donors.

Maternity Case

And, finally, came a girl of 22, with a baby in her arms. She was a very pretty girl, and a very bright one, and any baby fancier would have said the same of the infant she carried. She would not have been alive but for the blood of six donors. Her child had been born normally and apparently successfully, but then, owing to unforeseen complications, the mother's own life had been endangered by loss of blood.

She described how she felt when they brought her into the ward. " I suppose I know exactly what it feels like to die," she said. " I just felt the life pouring away from me. Then I saw them put a bottle by the side of my bed, and push something into my arm. I lay there and watched the blood dripping down into me. They made it drip quite slowly, and I counted two thousand drops before I gave up, and with every drop I felt the life coming back."

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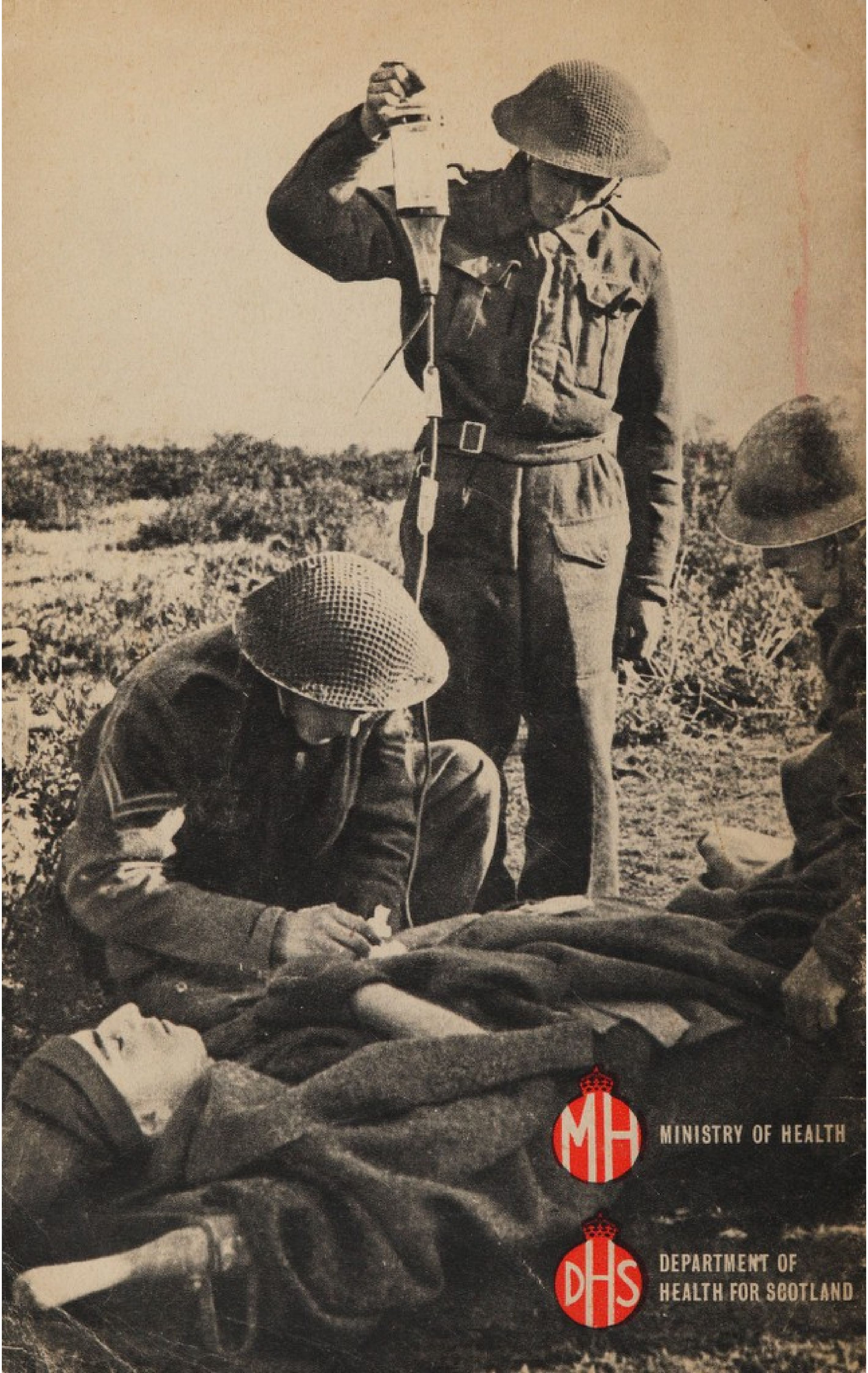
Before this world war is over, many thousands more must make their gift of blood. One out of every ten men wounded will need blood given by civilians in Britain ; and thousands of lives will be saved.

When the fighting is finished, the gift of life blood will remain. Just as mankind will benefit, on every day of peace, from penicillin, the sulphonamide drugs and other great advances in medicine which have been intensively developed in the stress of war, so the transfusion services will ensure that mothers and babies, workers injured in pit, field, factory, and street, who once would have died, will now live.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