

# electronics tomorrow

75p

A SPECIAL EDITION FROM  
*electronics today*  
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**WHAT'S  
HAPPENING IN:**  
Projects,MPUs,  
Hi-Fi,Calculators,  
Video,Audio...

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**Behind the scenes  
of STAR WARS**

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# INSIDE STAR WARS

**Specials Editor Jim Perry looks  
behind the scenes and inside the  
robots**

**B**Y the time this story is printed STAR WARS will have probably grossed 200 000 000 dollars worldwide. All those zeros are the result of six years work by writer-director George Lucas, and an end product that makes the TV series Star Trek look as spectacular as News at Ten!

As early as 1971 George Lucas had the idea of filming a space fantasy. Originally he wanted to make an up-to-date version of Flash Gordon — but couldn't obtain the copyright to the characters created by Alex Raymond. Thwarted by this setback, he started researching the possible sources that inspired Flash Gordon. After a fair bit of digging, he realised that the Flash Gordon concept was probably based on a series of books by Edgar Rice Burroughs (of Tarzan fame) about "John Carter of Mars." In turn it looks as though

Burroughs had been inspired by Edwin Arnold's "Gulliver on Mars" published in 1905. Jules Verne had preceded even this but never made his hero battle space creatures or have adventures on distant planets — the basis for a whole new concept (then) in adventure stories.

As soon as he finished American Graffiti George started writing Star Wars — that was in January 1973. He worked on the story virtually full time right up to and even during the actual filming in March 1976. At one point there were four different scripts, each one with a different blend of storyline and characters.

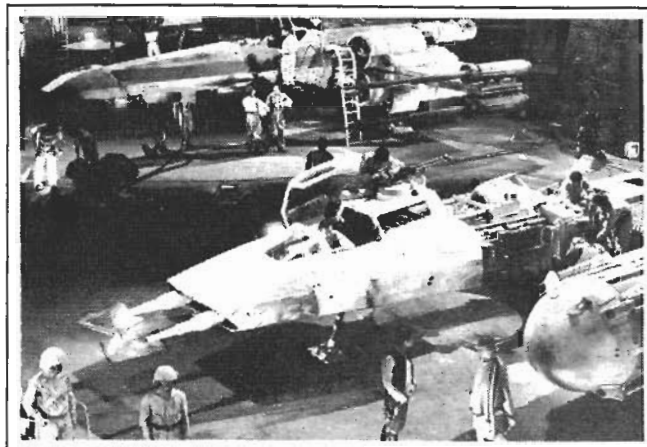
United Artists were the first to be offered the embryo idea, but they turned it down because they couldn't see the potential! Universal were more interested at first, but also gave it the thumbs down. Finally 20th Century Fox were persuaded to back it, but nobody thought it would be a big success — little did they know!

## New Worlds

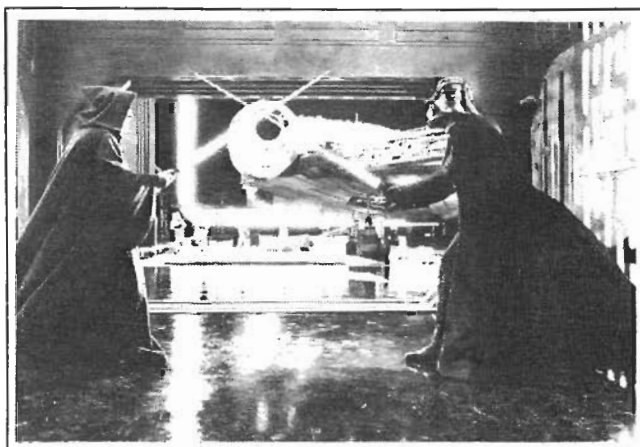
The first step after completing a satisfactory basic script concept was to visualize a whole new world. Collin Cantwell, who had worked on "2001 — A Space Odyssey," was brought in to design the spacecraft models. Starting off with simple sketches, Ralph McQuarrie began visualizing the characters, costumes, robots and scenery — finally producing a series of full colour paintings to give an idea of what George Lucas wanted in various scenes.

Meanwhile producer Gary Kurtz had the headaches of finding a suitable place to film, working out logistics and budgeting. In turn all American, North African and Middle Eastern deserts were visited; the aim was to find a suitable location for Tatooine, the desert planet home of hero Luke Skywalker. Finally the southern part of Tunisia was chosen, near Tozeur in the Sahara desert.

Partly as a result of the decision to film locations in Tunisia, but mainly because of the facilities and people available, the interior work was to be done at EMI



Han Solo (Harrison Ford) and Luke Skywalker (Mark Hamill) in the bottom right of the main hangar of the secret Alliance (hurray) fighter base.



Ben Kenobi (Alec Guinness) battling forcefully with the superevil (boo,hiss) Lord Darth Vader (David Prowse) near the captured Millennium Falcon space freighter.

printers, memory expansion cards (up to 62K), etc.

Launch date is January the first, so nip down to your Radio Shack shop (don't say that in too much of a hurry) and see it then.

Other systems that should be available during 1978 are those from Commodore (PET), Heathkit (H8) and Apple II based on MOS Technology's 6502 MPU.

### The Hard Sell

With all of these systems, one of the major problems faced by the manufacturer concerns how to market them. The problem being that nobody in this country has much idea of what type of person will want to buy a home system, for what purposes the system is likely to be used, or what form the retail outlet should take (mail order, local non-specialist shop or large dedicated computer store).

The first two questions are closely linked. It seems likely that the major use of these home systems, in the early stages at least, will be for information handling/manipulation tasks rather than control applications.

With over 5 000 teletext units already in use it would seem that there is already a demand for sophisticated data-handling media. The teletext experience also shows that people are prepared to accept data displays on a TV screen rather than on the printed page they are more used to.

Any home system should be able to provide, perhaps in conjunction with a teletext decoder or information on cassette tapes, a far superior system to that offered by present day teletext.

This then points to a large potential market for home computers. There are of course many other applications. The American experience is that people at first use the machine in tasks related to their job, doctors store lists of

drugs, shopkeepers calculate tax, but soon many more applications at first not considered, come to light.

The third point mentioned when discussing marketing was that of the form of the retail outlet.

Tandy, with their TRS-80, will probably adopt the policy of selling the machine in their many retail outlets. The problem with this sort of operation, as with mail order, is that the necessary technical back-up for the product may not be available.

Again turning to America, those shops which have been most successful in this field have been those which have provided competent advice at the time of purchase, plus good after-sales service.

A lot of thought is going into the marketing plans of the various manufacturers and the next year should show how successful the various strategies are.

### And Now the Soft Sell

Having had a look at the hardware we can expect to see appearing over the next few months, I shall now turn to software.

Just as most systems aimed at the home seem to follow the same pattern of hardware configuration, most seem to have adopted BASIC as their high-level language.

BASIC was originally formulated with large mainframe installations in mind, and whilst easy to learn and fairly powerful, it is not necessarily the most suitable language for home use on micros.

Names like FLEX, SMALLTALK and perhaps APL, may be heard soon in an effort to bring purpose-built languages into the home.

I think that the next year or so will see a vigorous development of software as people begin to realise that the difference between a good machine and one that's OK will be in the quality of software, and not in how many lights and levers a machine has.

Commodore's PET shown in our photograph is typical of the small, micro based, computers that will appear on the British market during 1978.



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### Bubbles Finally

Finally just a word about new products appearing on the professional market: bubbles, CCD, single chip computers, etc. These products are very expensive at the moment and even if the usual price/learning curves are followed, it will be some time before they appear in devices offered to the home user.

This means that it will be some time before (as your latest memory card blows up in a puff of smoke) you can coin the phrase "I'm forever blowing bubbles".

So to sum up, the next year will be a year of growth rather than startling technological developments, after which we shall see real computing power in a large number of homes for the first time. Whilst Arthur C. Clarke's hand-held "Minisec" is some way off, I doubt that it will be the twenty-third century before a hand-held computer with large computing power will appear on the shelves of your local matter transmitter/receiver.

The potential problems that the home computing revolution will produce are not a subject for these pages, but I hope someone, somewhere is thinking about them. □

Studios in Elstree. It was the only studio complex in England or America that could provide up to nine sound stages simultaneously, and the technical staff are among the best in the world.

Production designer John Barry and his crew began designing and building the huge number of props and sets in August 1975. In order to make things look realistic £25 000 was spent on junk and scrap metal; anything from sewage pipes to jet engines were used to make scenery look realistic. One of the interesting aspects of Star Wars is that everything looks used — just like real life!

The job of making the robots was given to John Stears (alias Special Effects Worldwide), who won an Academy Award for his special effects in Thunderball. John had also worked on six other Bond movies — he fitted out the legendary Aston Martin that did everything except make tea!

John's job was to turn Ralph McQuarrie's illustrations into reality (or as near as possible). He was also responsible for the production effects. The main robot is R2-D2 (Artoo Detoo): the one that looks a bit like a dustbin with three legs. Artoo's partner is C-3PO (See Threepio), an android type. The only robot not made by John was Threepio, as he was just a casing designed by art director Norman Reynolds and sculptress Liz Moore — with Anthony Daniels entombed inside.

Besides Artoo types there were four other basic robot types used in the film, these were the Umbrella-type, Stick-type, Dome-type and Box robots. All of these were radio controlled — internal shots are given later in this article.

### Now You See It . . .

As well as the variety of robots, John designed the Speeders used as transport on Tatooine, the multitude of explosions and the light sabres. The Speeder shells were moulded in fibreglass, and supported on a boom arm; after filming the boom was painted out frame by frame. ▶



Our dynamic duo C-3PO and R2-D2 watch helplessly as Alliance (hurray) crewmen defend their ship against Imperial stormtroopers (yugh).



Imperial stormtrooper (hiss) blasting after Princess Leia inside the Alliance ship.



Luke Skywalker, Han Solo, Chewbacca (Peter Mayhew) and the lovely Princess Leia Organa (Carrie Fisher) trapped inside the Death Star.



Luke Skywalker having a natural break during the Tunisian location work. The Speeder suspension system can be seen clearly in the background.

The light sabre effect was produced with the aid of reflective and non reflective facets of the sabres. With a light mounted on the camera, the sabres appeared dark if their non-reflective part was towards the light, and glowed when revolved to expose their reflective section. By spiraling the reflective portion and spinning the sabre the effect of the light moving out was created.

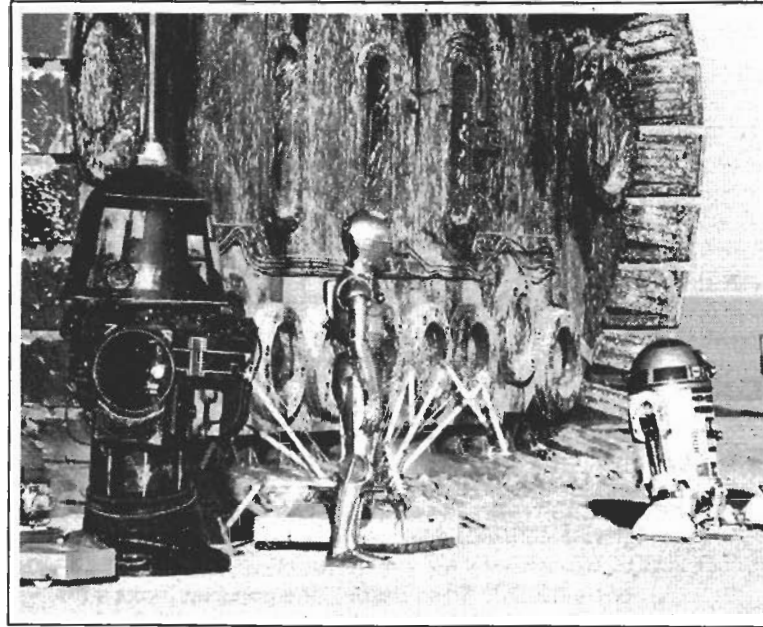
Even though John Sears is an electro-mechanical wizard and special effects veteran, he hadn't made anything quite like Artoo and his (its?) fellow robots — even though his hobby is radio-controlled models. Asking for advice at St. Mary's College (University of London), where he met Professor Thring, the robotics expert, and Queen Mary's Hospital in Roehampton where he met artificial limb specialists, he gained useful information on pneumatics and electronics. The only

problem was that when told the time available, everyone said it was impossible! In fact John did the impossible — with one exception: there wasn't enough time to produce a version of Artoo that wobbled on two legs.

The wobble effect was needed to make Artoo a bit more human and, as a final solution, a special Artoo casing was

constructed for 3ft. 8in. Kenny Baker to wobble around in! Simple way of telling which version is in a scene is two legs Kenny, three legs the real Artoo with radio control. In March, 1976, the production unit moved into Tozeur in the South of Tunisia, to begin the transformation of desert into desert (from a different galaxy), and construction of massive Jawa transport vehicles. The Algerian army caught sight of these massive props and thought they were real!

After eight weeks of preparation the filming started. During the first week the entire crew had to wear sand goggles due to a big sandstorm. The filming lasted two-and-a-half weeks on location before moving to Elstree for the next 14½ weeks, where all nine sound stages were filled with John Barry's 30 sets. Planets, starships, caves, control rooms, cantinas and a vast network of corridors from inside the Death Star were at Elstree — but the Alliance's secret hangar full of X-wing and Y-wing fighters



Owen Lars (Phil Brown), uncle of Luke Skywalker, being shown the Jawa robot collection by the chief Jawa (Jack Purvis). The

had to be built at Shepperton Studios, because it was the only place in Europe big enough!

When on location all the robots had to be cleaned every day — the sand and salt got in everywhere! One problem arose with the radio control systems because of static-charged windborne sand particles present in the Sahara; an extra aerial wire had to be attached to Artoo. Also being miles from nowhere the internal batteries had to be charged from mobile generators, which also had to be maintained. Trying to keep track of up to 30 sets of batteries is guaranteed to give anyone a twitch! Artoo and company were operated by John Stears and his crew, with Dick Hewitt (of Compact Video Systems) supervising the electronics.

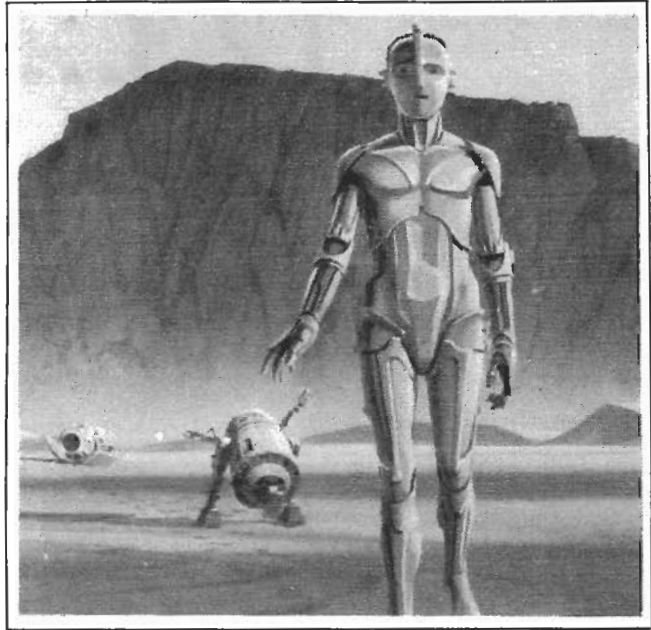
### Built from Scratch

As well as the robots and mechanical effects, Star Wars uses the most advanced optical and miniature effects — the deep space shots, laser guns, etc. In June 1975 John Dykstra was asked to supervise all the photographic special effects. There was a slight problem — no commercial facility had either the time or even equipment to produce what was required — so John built Industrial Light and Magic Corporation, from scratch, in an empty warehouse in the San Fernando Valley.

The ILM complex included a carpentry shop and machine shop, which had to build or modify the special camera, animation equipment, editing and projection equipment needed to produce the effects. Other departments included optical printing (for putting the many different layers of film together), a rotoscope department (for matte work and general backgrounds) and a library section for keeping track of the thousands of pieces of film.



huge sandcrawler in the background was mistaken for a military vehicle by the Algerian army.



Ralph McQuarrie's original illustration of R2-D2 and C-3PO, pictured after their landing in the deserts of Tatooine.

### Dykstraflex Films O.K.

The most important part of ILM is the Dykstraflex camera, this is based on an old VistaVision camera, linked into a computer. The VistaVision camera runs 35mm film through sideways, like a 35mm still camera, whereas normal movie cameras run the film vertically — the benefit is increased resolution, which is needed when up to 12 shots are put together on one print. The computer is used to store movement information and provide "action replay" of the camera movement, with control of seven separate parameters simultaneously.

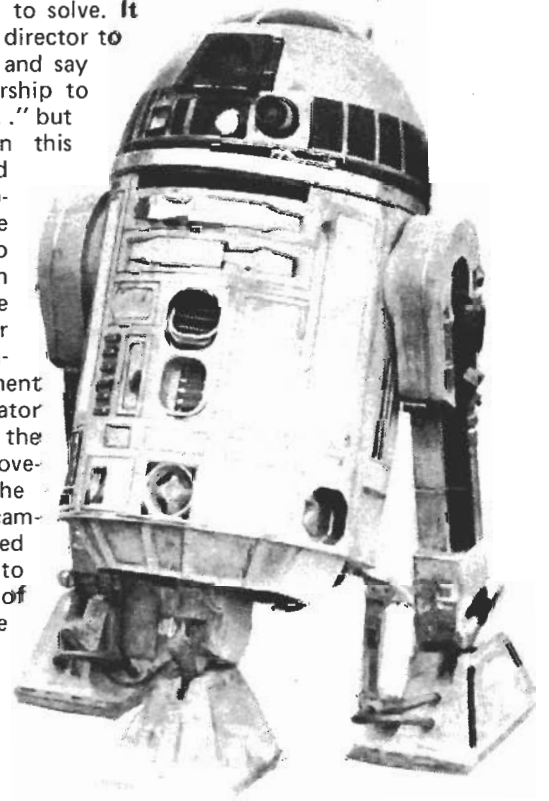
Each of the 365 special effects needed between two and 12 separate exposures of film, in all 3 838 exposures were needed. For example in the battle sequence you see an X-wing fighter swooping and soaring over the Death Star — in fact, the model of the X-wing never moved an inch! The camera moves, creating the illusion that the fighter is moving, the Death Star is filmed separately with different camera movements. The two exposures are then printed together to create the impression of X-wing swooping over revolving Death Star — not to mention more fighters, laser flashers, stars, etc.

This is where the computer comes in. If the angle of the camera changes during a shot, the other shots change as well — hence each separate frame has to be exactly matched for each different component of the composite shot. The computer remembers everything and moves the camera accordingly — simple, but until the Dykstraflex, no camera could do it.

To create realism in the dogfight scenes, thousands of feet of World War II movies were viewed, together with storyboards. By studying the real life movements of the

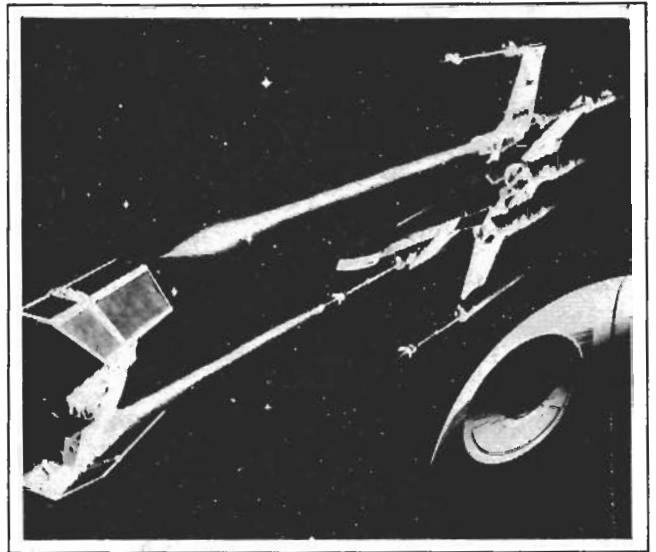
planes, the model shots were planned to be the most realistic ever made — they succeeded.

Even with the aid of the Dykstraflex the ILM crew had several problems to solve. It was easy for the director to move his hand, and say "I want the starship to move like this . . ." but to actually turn this into a finished shot was a problem. Firstly the movement had to be put down on paper, so that the camera operator could try and emulate the movement — then the operator had to teach the computer the movement, in fact he had to 'fly' the camera over the fixed model. Needless to say at the end of the filming the camera operators were all accomplished pilots! □

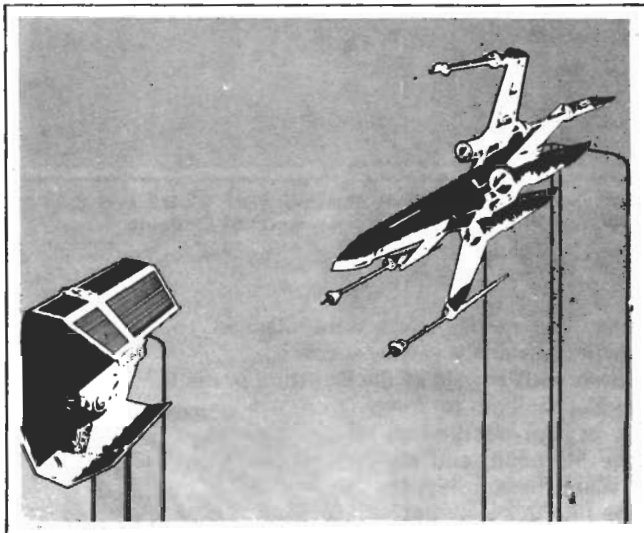


# 1,2,3...

An example of the shot sequence needed to produce the stunning optical effects in Star Wars . . .



Final product, the assembled film print as seen by the cinema goer.



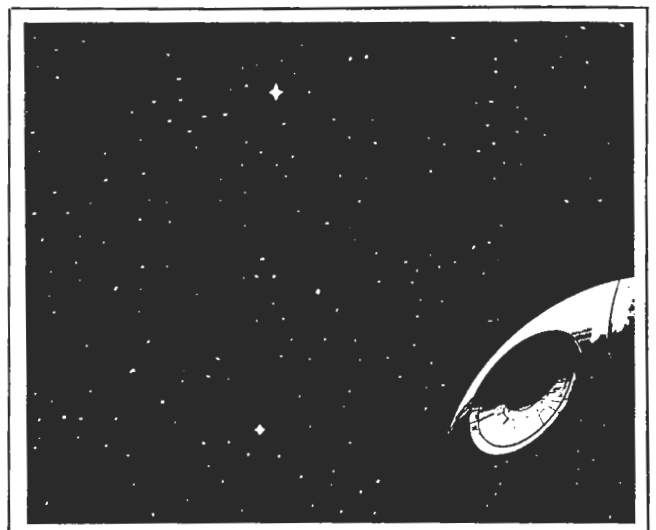
Step 1, models are fixed in their relative positions on a blue background.



Step 2, a 'garbage' mask is used to obliterate unwanted images from the frame.



Step 3, laser flashes are added in the third exposure.



Step 4, background detail of stars and Death Star complete the frame.



**Contrary to some reports, most of the R2-D2 sequences were with a real robot, built by mechanical wizard John Stears — read all about the real R2-D2 here!**

Two versions of R2-D2 were made, one for Kenny Baker to fit inside and the three-legged radio controlled version. Our interest is centred on the radio controlled version.

R2 D2 has three forward speeds, but no reverse, and is steerable. Provision is made for the change from two legs to three legs by radio control, also when tilted the third leg drops automatically. The reason for this is that R2 would fall over if left on only two legs!

**Mechanical**

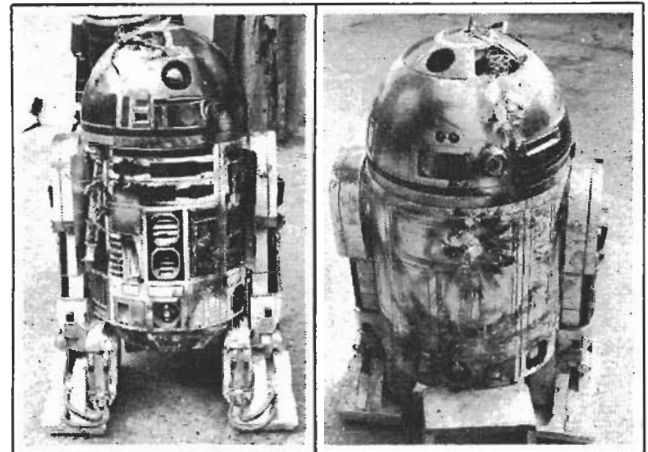
In order to achieve forward motion, the two rear legs have individual traction motors which drive twin inline wheels. Steering is via the front drop leg, with a proportional self centring servo unit. The twin wheels in the steering foot remain parallel to the other wheels during turns.

The front leg and foot can be retracted inside the body. When the front leg drops it is held at the correct distance by wires, R2-D2 can then move off at full speed.

The casings for all the R2s were specially made by a company called Petric Engineering for the modest sum of £18 000, which may seem a trifle high — but they were precision pieces of engineering to the highest standard, in fact John Stears says they were excellent value.

**Cleaning Up**

For several of the scenes R2-D2 was made to appear thoroughly blasted, or covered in grime. The only way was to virtually blast it in real life, and then clean up for the next shot. While in the Tunisian desert John Stears was also continuously cleaning real dirt and sand from R2, it got in everywhere!



Top of page, rare shot of Kenny R2 being chased by radio R2. Above, R2-D2 in two stages of disorder — heart-breaking work, wrecking such a nice machine! Left, R2-D2 in action as a fire extinguisher.

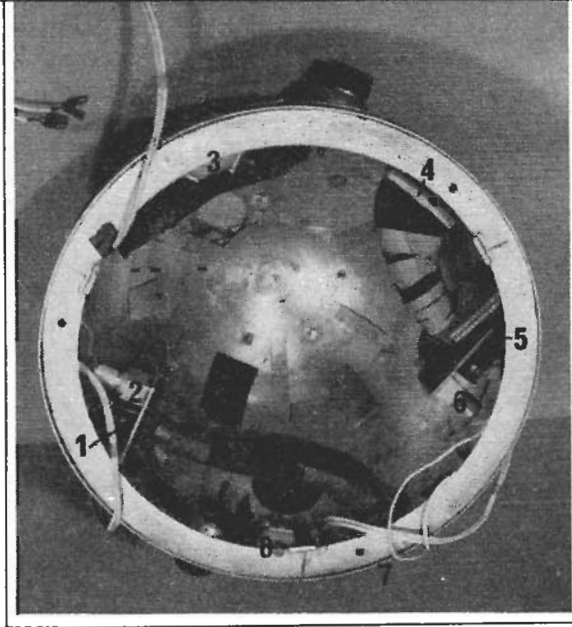


## General

1. Radio control gear
2. Head ring
3. Shoulder bearing
4. Two 6V batteries for lights and steering (removable)
5. Six 6V batteries for traction (not removable)

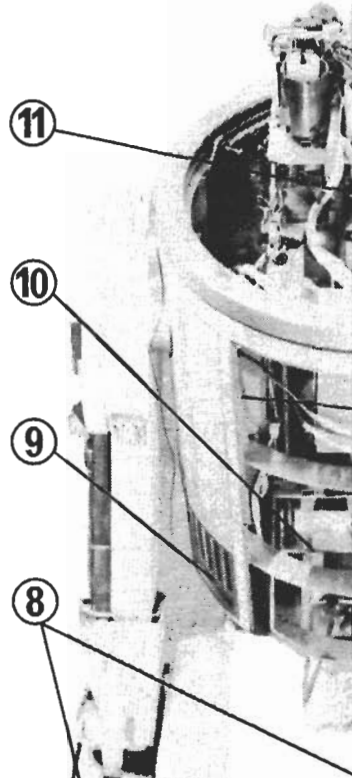
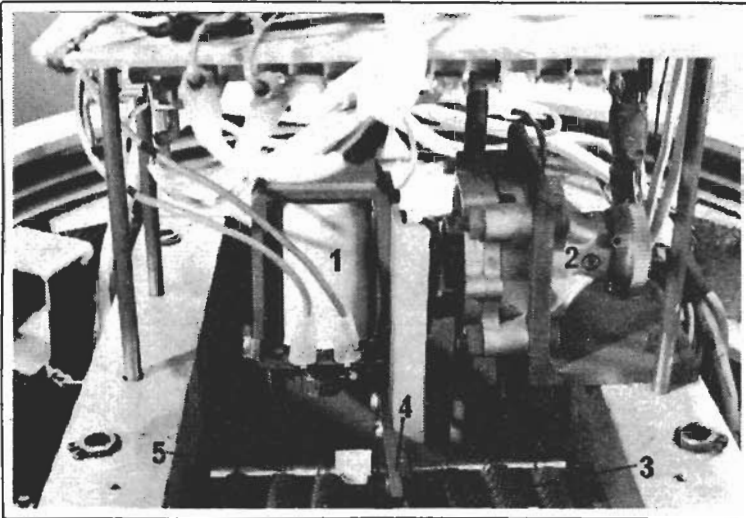
## Head Interior

1. QI light source (front)
2. Coloured disc motor (front)
3. Pulsating lights (green/yellow)
4. Fibre optic display (rear)
5. QI light source (rear)
6. Coloured disc motor (rear)
7. Fibre optic display (front)
8. Pulsating lights (red/blue)



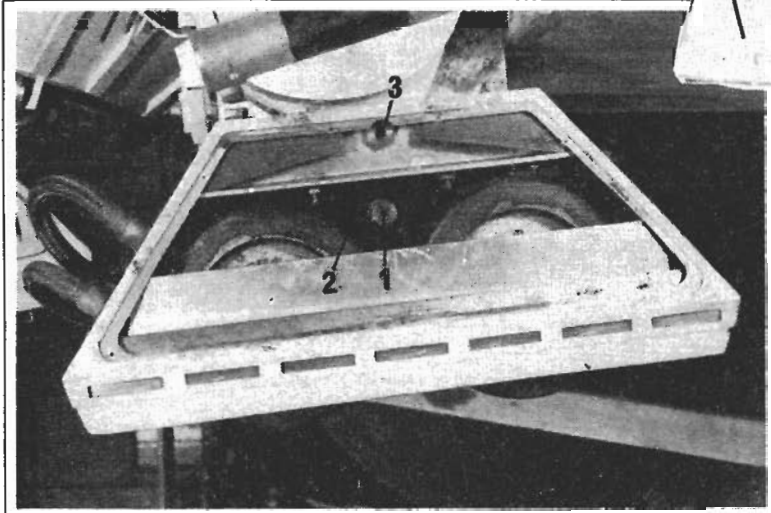
## Leg Drop

1. Leg drop solenoid
2. Damper
3. Body tilt tension springs
4. Leg drop locking arm
5. Leg drop locking rod



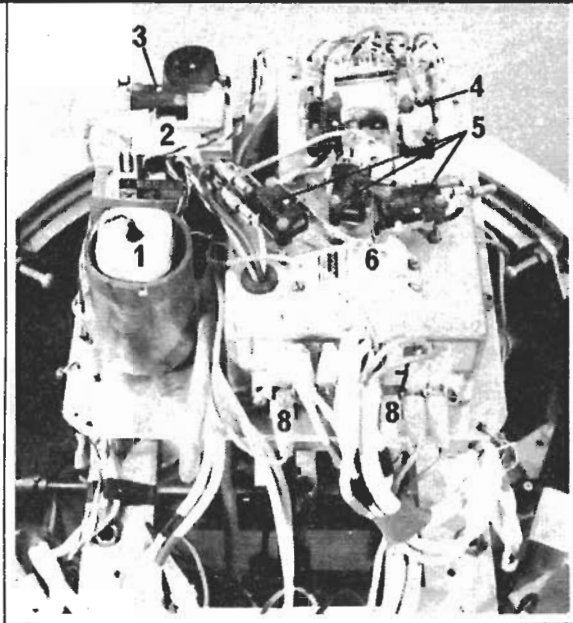
## Driving Foot

1. Drive front gear box
2. Chain sprocket, both wheels in each foot driven by single chain
3. Foot retaining pin



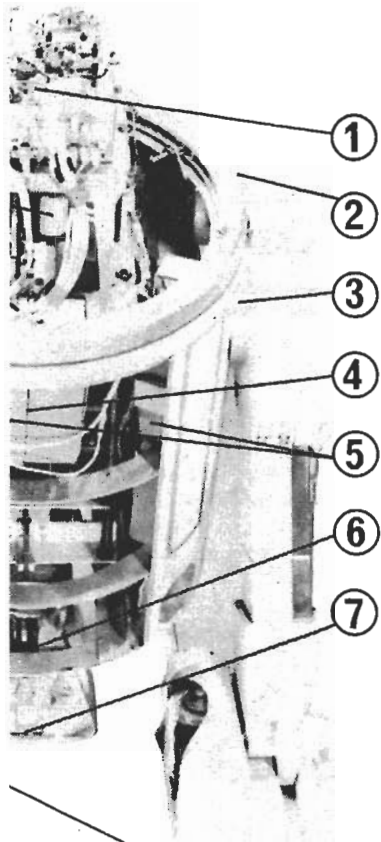
# D2

- 6. Headlight switch
- 7. Front foot (steering)
- 8. Rear feet (traction)
- 9. Radio on/off switch
- 10. Led drop (mechanical)
- 11. Leg drop (electrical)



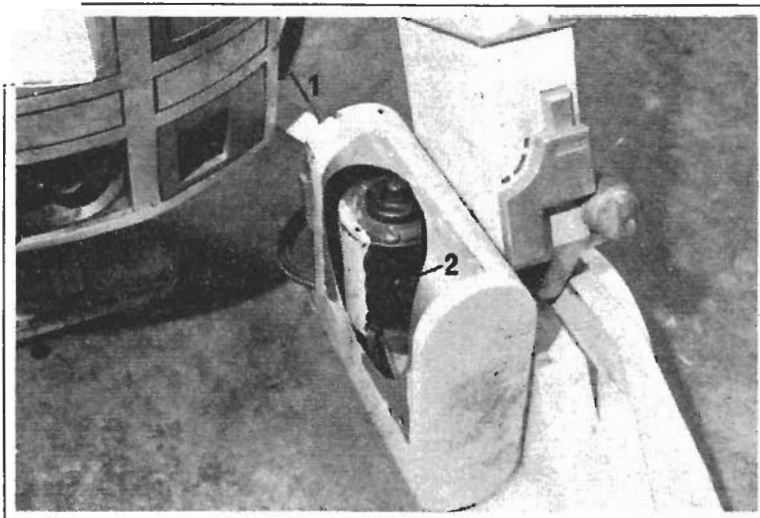
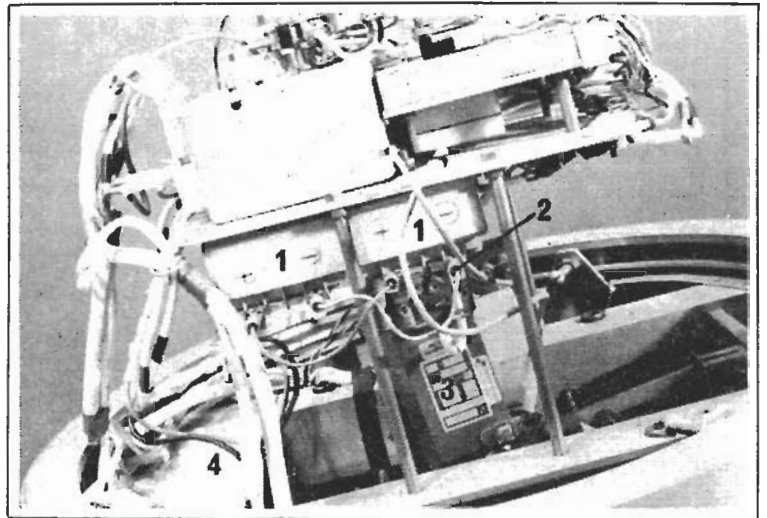
## Radio Control Gear

- 1. Deac
- 2. Main receiver
- 3. Leg drop servo and microswitches
- 4. Steering servo and microswitches
- 5. Speed control microswitches
- 6. Speed control servo
- 7. Traction motor connections
- 8. Traction batteries charge terminals



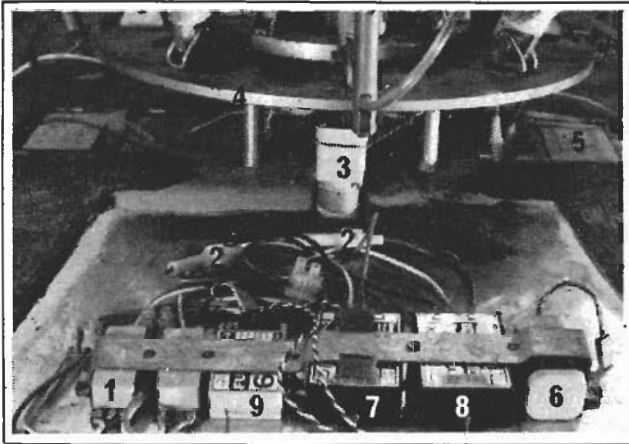
## Pulsating Light Drives

- 1. Pulsating light control box
- 2. Pulsating light connections
- 3. Leg drop solenoid
- 4. Light and steering batteries.



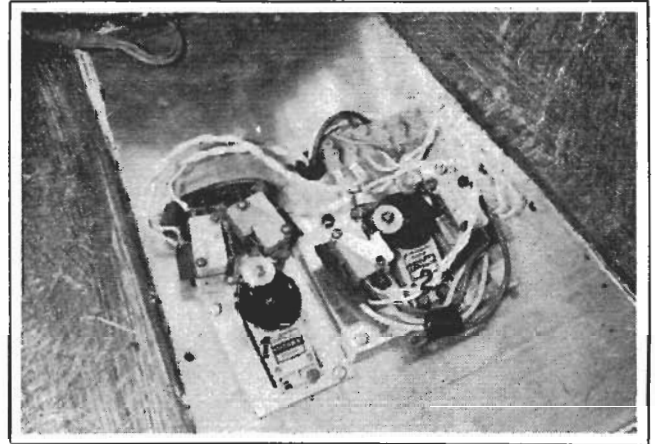
## Drive Motor

- 1. Leg distance wire and strut
- 2. Traction motor, 36V for full speed, 12V or 24V for reduced speed



## Radio Control

1. Suppressors
2. Fuse holders
3. Turntable motor
4. Arm turntable
5. Batteries
6. Deac
7. Left speed control
8. Right speed control
9. Receiver



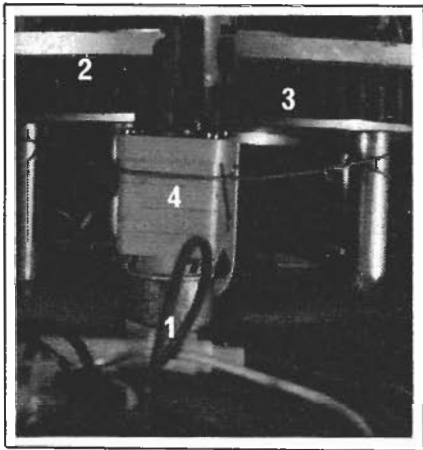
## Compartment

1. Eyes turn servo
2. Turntable servo

# UMBRELLA

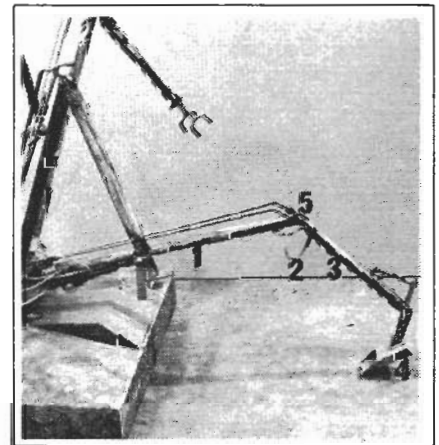
## General

1. Dummy aerial
2. Radio control cover
3. Real aerial
4. Arm turntable
5. Rotating head
6. Pneumatic arm
7. Servo cover
8. Battery compartment



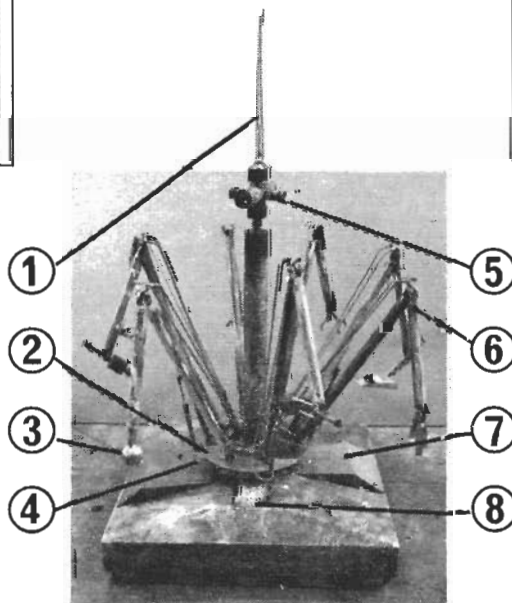
## Turntable Motor

1. Drive motor
2. Turntable
3. Ring gear
4. Gearbox

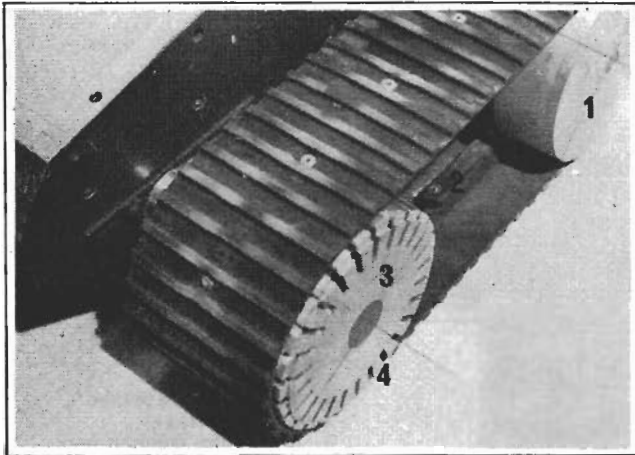


## Arm

1. Raise/lower ram
2. Airlines
3. Scoop ram (inside)
4. Scoop
5. Elbow



# STICK



## Track

1. Idler wheel
2. Track guide
3. Drive wheel
4. Sand escape vents

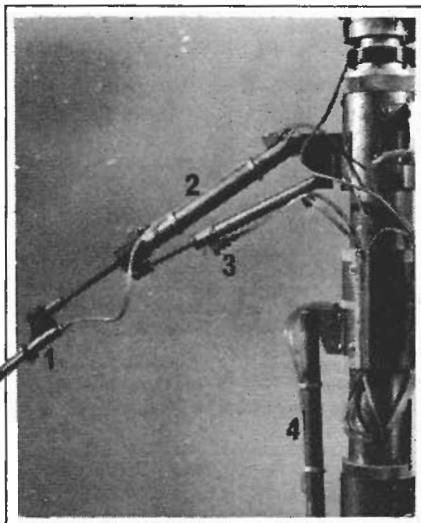


## Head

- |             |                           |
|-------------|---------------------------|
| 1. Eyes     | 5. Eyes up/down crank     |
| 2. Pivot    | 6. Counter balance spring |
| 3. Slipping | 7. Eyes up/down motor     |
| 4. Brush    | 8. Slip ring feed         |

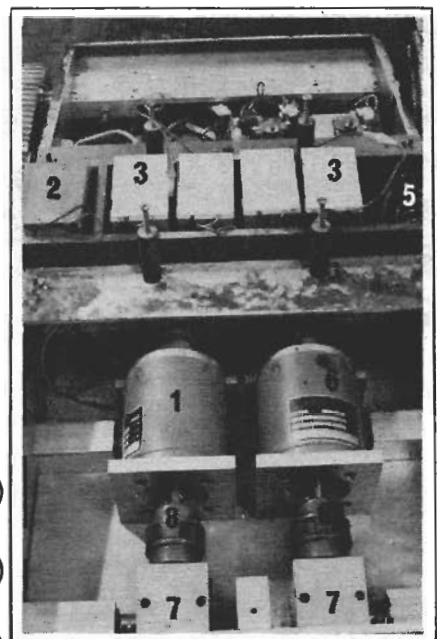
## General

1. Eyes pivot
2. Head swivel
3. Practical arm
4. Stick
5. Drive wheels
6. Battery compartment
7. Receiver on/off
8. Real aerial
9. Pneumatic connections



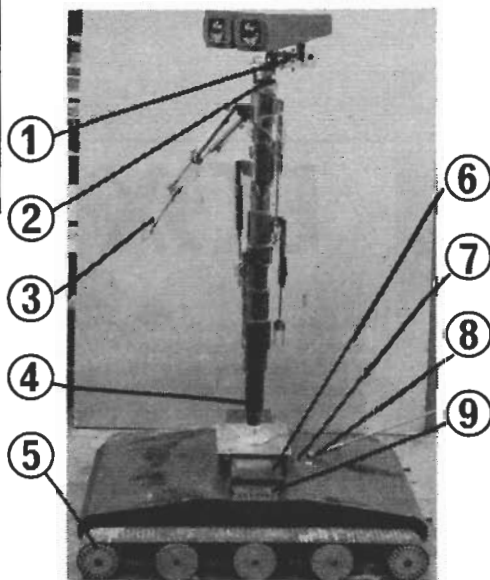
## Arm

1. Claw ram
2. In/out ram
3. Up/down ram
4. Dummy ram



## Base

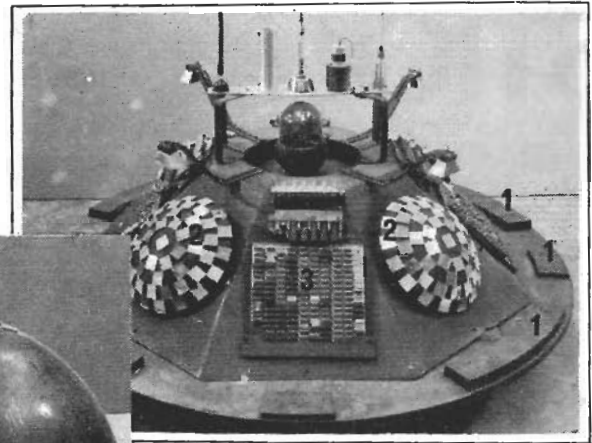
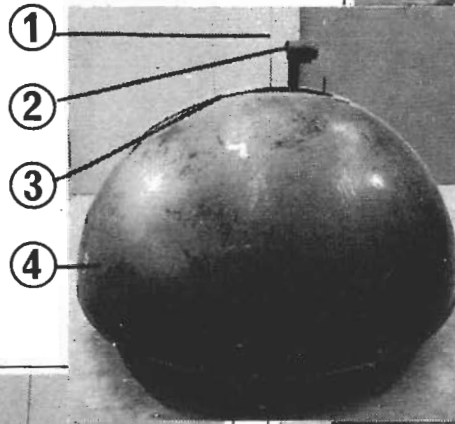
1. Right traction motor
2. Auxiliary battery
3. Traction batteries
4. Receiver
5. Pneumatic connections
6. Left traction motor
7. Gearboxes
8. Flexible couplings



# DOMES

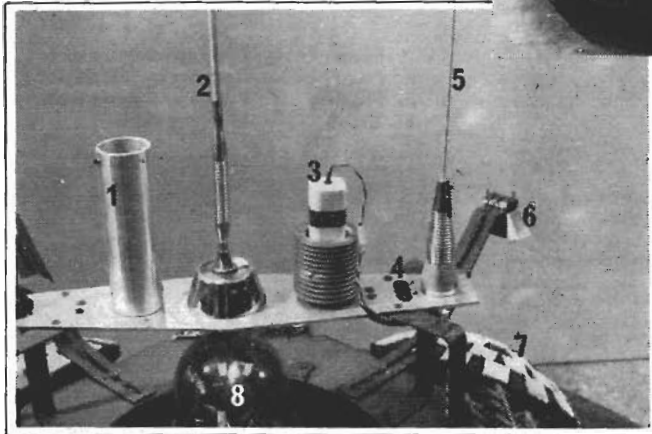
## General

1. Real aerial
2. Eye
3. Slot
4. Perspex dome



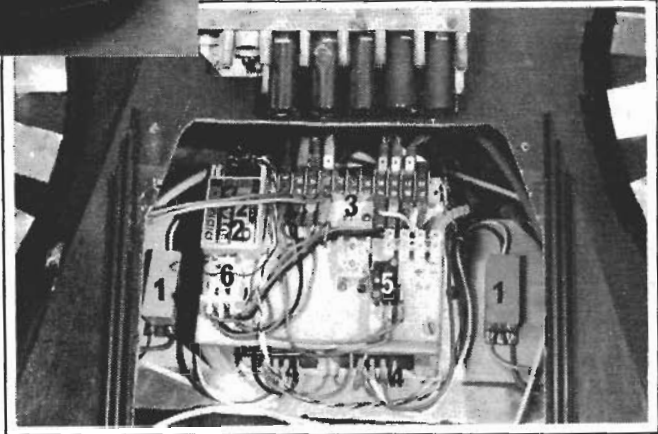
## Super Structure

1. Dome locating blocks
2. Mirror domes
3. Electronics compartment



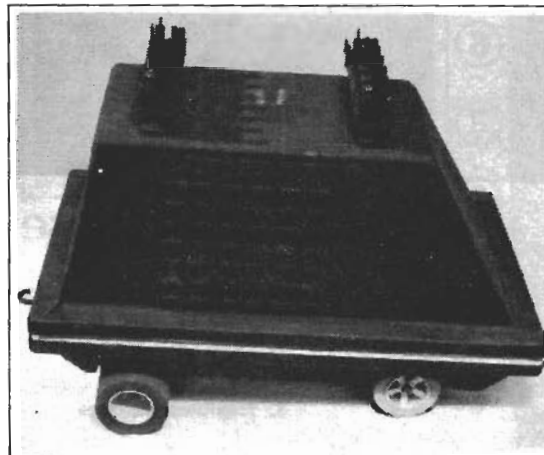
## Bridge Assembly

- |                    |                    |
|--------------------|--------------------|
| 1. Eye Socket      | 5. Real aerial     |
| 2. Dummy aerial    | 6. Oil light       |
| 3. Deac            | 7. Mirror dome     |
| 4. Receiver on/off | 8. Flashing beacon |



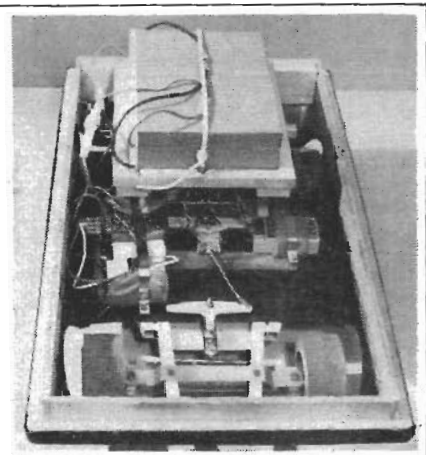
## Radio Control Gear

- |                     |                   |
|---------------------|-------------------|
| 1. Suppressors      | 4. Speed controls |
| 2. Receiver         | 5. Lighting servo |
| 3. Connecting block | 6. Lighting relay |



# BOX

Most people think the Box robot should have been called the Rat robot, its the one that runs around the Imperial Death Star. A Radio controlled yellow streak, makes Box robots turn and run when confronted with a Wookiee!



ETI's Editor, Halvor Moorshead, went to see *Star Wars* in North America, where it has been playing to packed houses since the summer.

# ONCE UPON A TIME

George Lucas in his book of the film states "... instead of making 'isn't-it-terrible-what's-happening-to-mankind' movies ... I decided I'd try to fill the gap. I'd make a film so rooted in imagination that the grimness of everyday life would not follow the audience into the cinema, in other words, for two hours, they could forget." The fact that *Star Wars* has overtaken *Jaws* as the fastest box office success of all time shows that he's succeeded.

SF fans have been badly served until now, the notable exception Kubricks '2001' but in that you were obliged to argue for hours about the inner meaning of it all. *Star Wars* is uncomplicated. The heroes are all good, the baddies are super evil; that in itself isn't unknown in the current cinema but as often as not such stories are 'self-spoofs'.

The effects are brilliant — they're almost dominant — and the director has avoided the temptation of over-displaying a set, or an effect simply because it was expensive to arrange.

We see believable space shops and background. We see sunset on a planet of a binary star pair but they don't explain it or make a meal of it — SF addicts will understand. Alien creatures and androids continually crop up and are extremely well done.

The story? The book is available and reading it in advance won't spoil the movie — it may even make it more interesting but the story is almost irrelevant. Mix up the 'Dam Busters,' 'Battle of Britain,' 'The Magnificent Seven' and add characters like Merlin and Laurel and Hardy and you've got the gist of it: this isn't meant unkindly.

We're told in the opening sequence that Princess Leia has acquired vital plans from the controllers of the all-evil Galactic Empire and is trying to deliver them to the freedom-loving rebels, the last vestiges of the Republic, the Galactic organisation which preceded the Empire. It doesn't occur to us to ask what a Princess has to do with a Republic but that is only because we have abandoned the complexities of our world. (Some of us must take some satisfaction from the fact that the Galactic Empire is apparently controlled by the British). The film does give the impression that a lot has been left on the floor of the cutting room and, as most of the audience are spending most of their time looking at effects, it's a bit difficult to follow occasionally but not enough to spoil your enjoyment.

If you note a measure of enthusiasm, you're right. I did get in free to see the film — and I went to see it again the next night I enjoyed it so much! □



Above, John Stears gropes under R2-D2 on location, even the best robots need repairs. Below, Kenny Baker takes his head off in between scenes.



Thanks are due to John Stears and 20th Century Fox for their help in producing this feature. All photographs are world copyright 20th Century Fox Corporation.