VOLUME CIX NUMBER THREE

THE NATIONAL GEOGRAPHIC MAGAZINE

MARCH, 1956

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The National Geographic Society and the Royal Ontario Museum in 1951 explored and measured newly found Chubb meteor crater, 11,500 feet in diameter, in northern Quebec.

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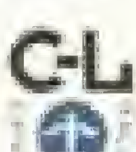

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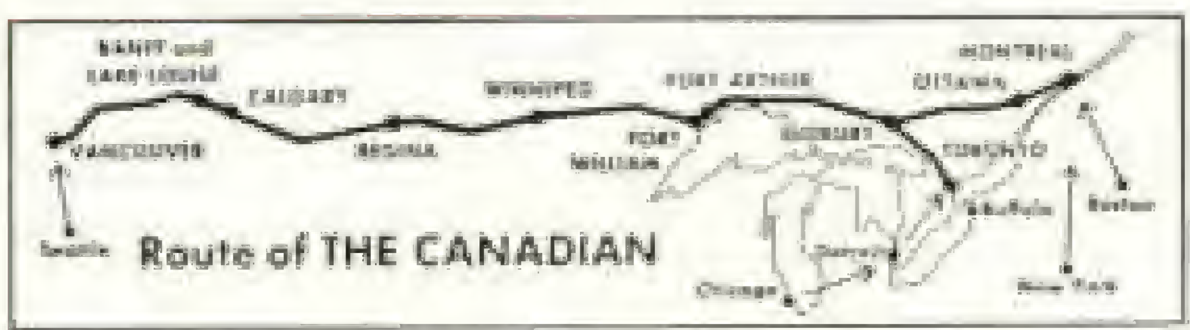

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OIL AND THE RAILROADS:

How Free Men Work Together

by F. G. GURLEY

President of the Santa Fe Railroad

Fred G. Gurley, president of the Santa Fe Railway System, has been a railroader for almost 50 years. A pioneer in modern motive power equipment, Mr. Gurley is a great believer in Diesel Fuel. He is in an excellent position to evaluate the oil industry's part in improving American railroad transportation.

THE historic relations between the Santa Fe and America's oil industry date all the way back to 1894. In that year, a California oil company and the Santa Fe worked together in our shop at San Bernardino, Calif., to develop the first oil burner which could burn oil successfully in the firebox of a steam locomotive.

By 1896 more than half of the locomotives we had in service in Southern California had been converted into oil burners. That same year we developed other interests in oil because the Santa Fe secured leases covering some 300 acres of prospective oil land in the Olinda district of California and our first well was drilled in 1897.

So, for almost 60 years the Santa Fe, now America's largest completely Dieselized railroad, has not only been burning oil in its locomotives, but also has been engaged in producing oil. As a result, there has been an understanding of some of the problems in the oil industry and a sympathy for their difficulties, as well as a sincere admiration for the great accomplishments of the petroleum industry.

One of the finest examples of two American industries working toward a common goal was the highly successful teamwork between the oil industry and the railroads in winning the "Battle of Transportation" during World War II.

During those war years the railroad industry carried over 97% of all organized military traffic and more than 90% of the war freight. To accomplish this record-breaking transport job, tremendous supplies of fuels and lubricants were required by the railroads and were produced and delivered by our oil industry.

The spirit of teamwork which paid off for us then remains alive today. Research scientists of the railroads and the oil industry are continually experimenting on improved fuels and lubricants and new uses for petroleum products toward transportation progress.

We refer to our modern method of railroading as "Progress That Pays Its Own Way." The same can be said of the oil industry. But this will continue only as long as we maintain our American system of private free enterprise – the greatest force for scientific and industrial development the world has ever known.

This is one of a series of reports by outstanding Americans who were invited to examine the job being done by the U.S. oil industry. This page is presented for your information by The American Petroleum Institute, 50 West 50th Street, New York 20, N.Y.

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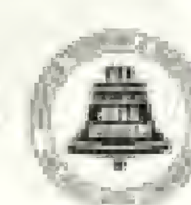

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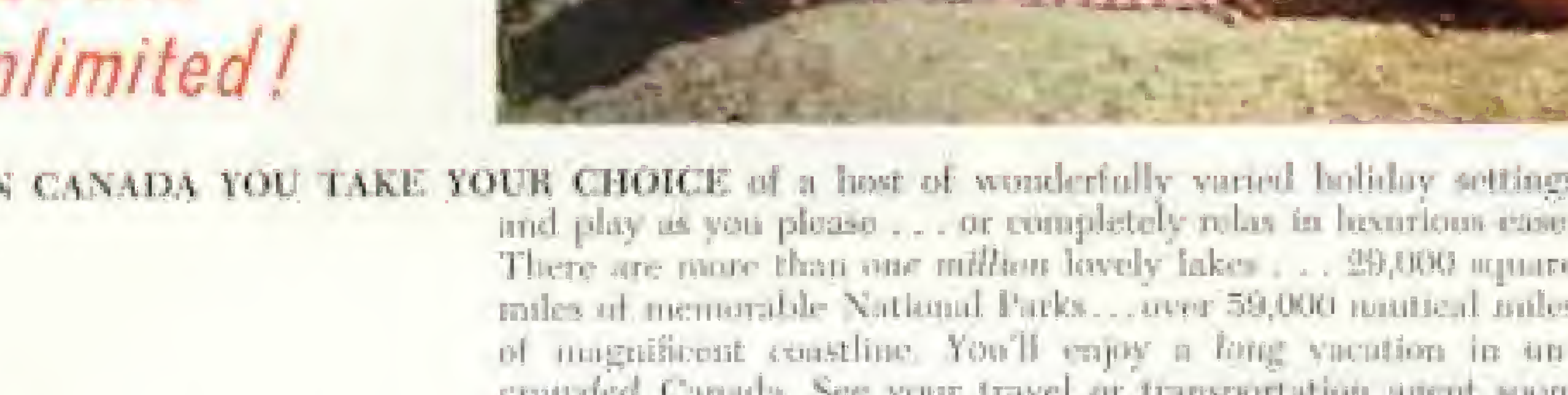

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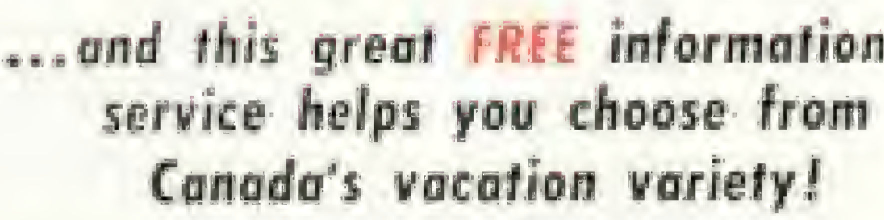

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The need for a garden has been part of the American character from the very beginning. The Pilgrim dames of Plymouth brought flower seeds with them to brighten this wild new land and many an overcrowded covered wagon rumbled west with a few dusty geraniums bobbing on the load. It's a proud banner that the ladies of the garden clubs have inherited from the "southern belle." They carry it exceedingly well.

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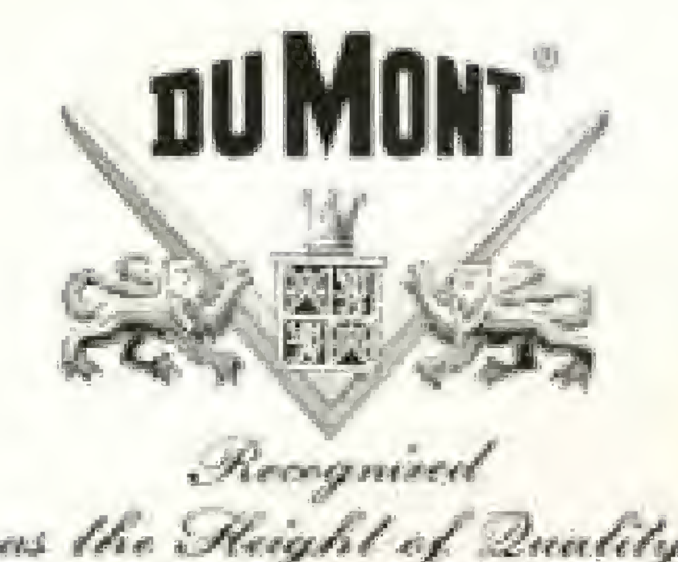

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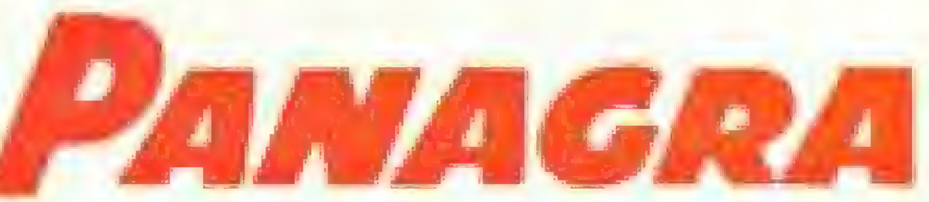

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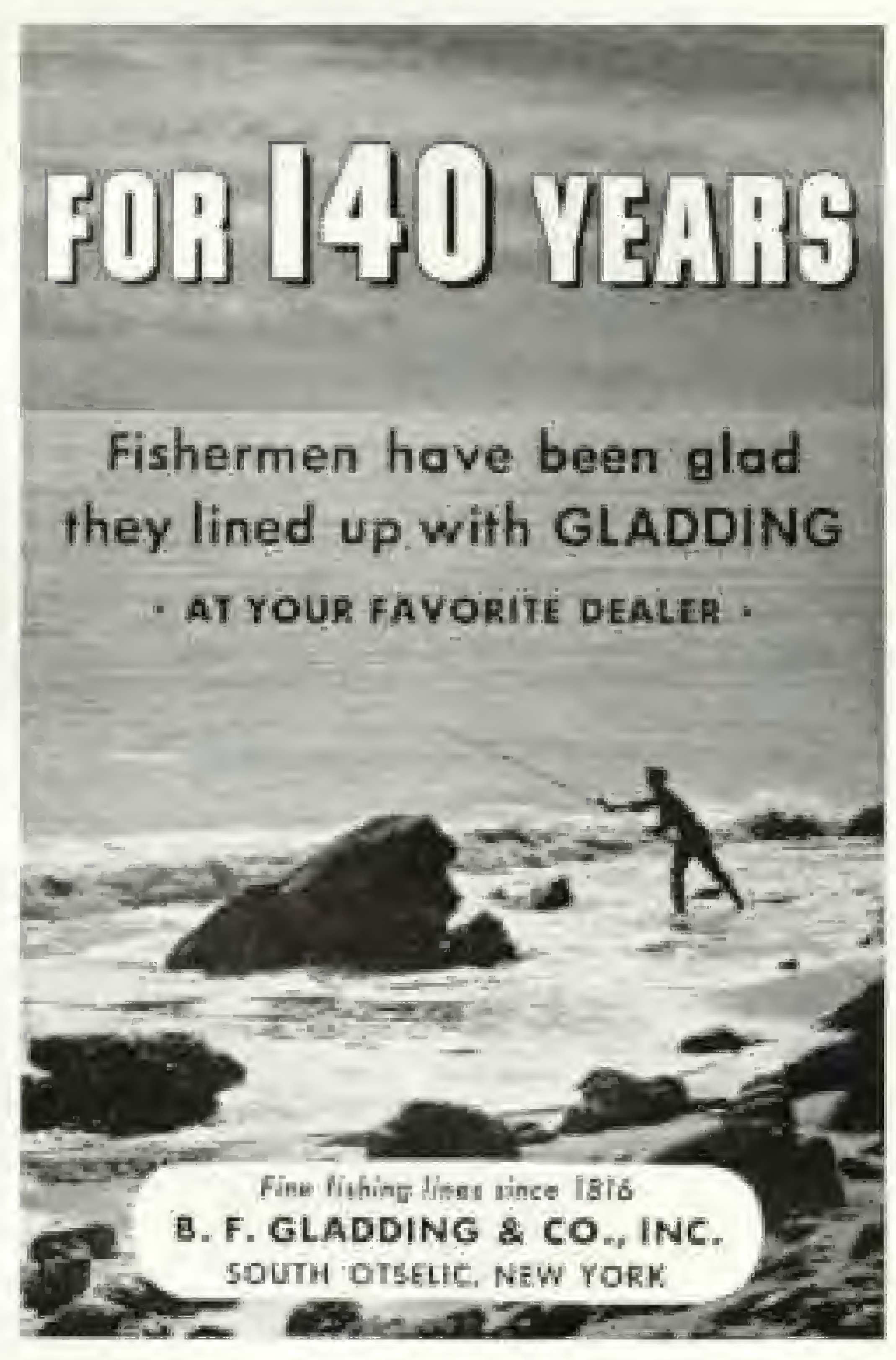

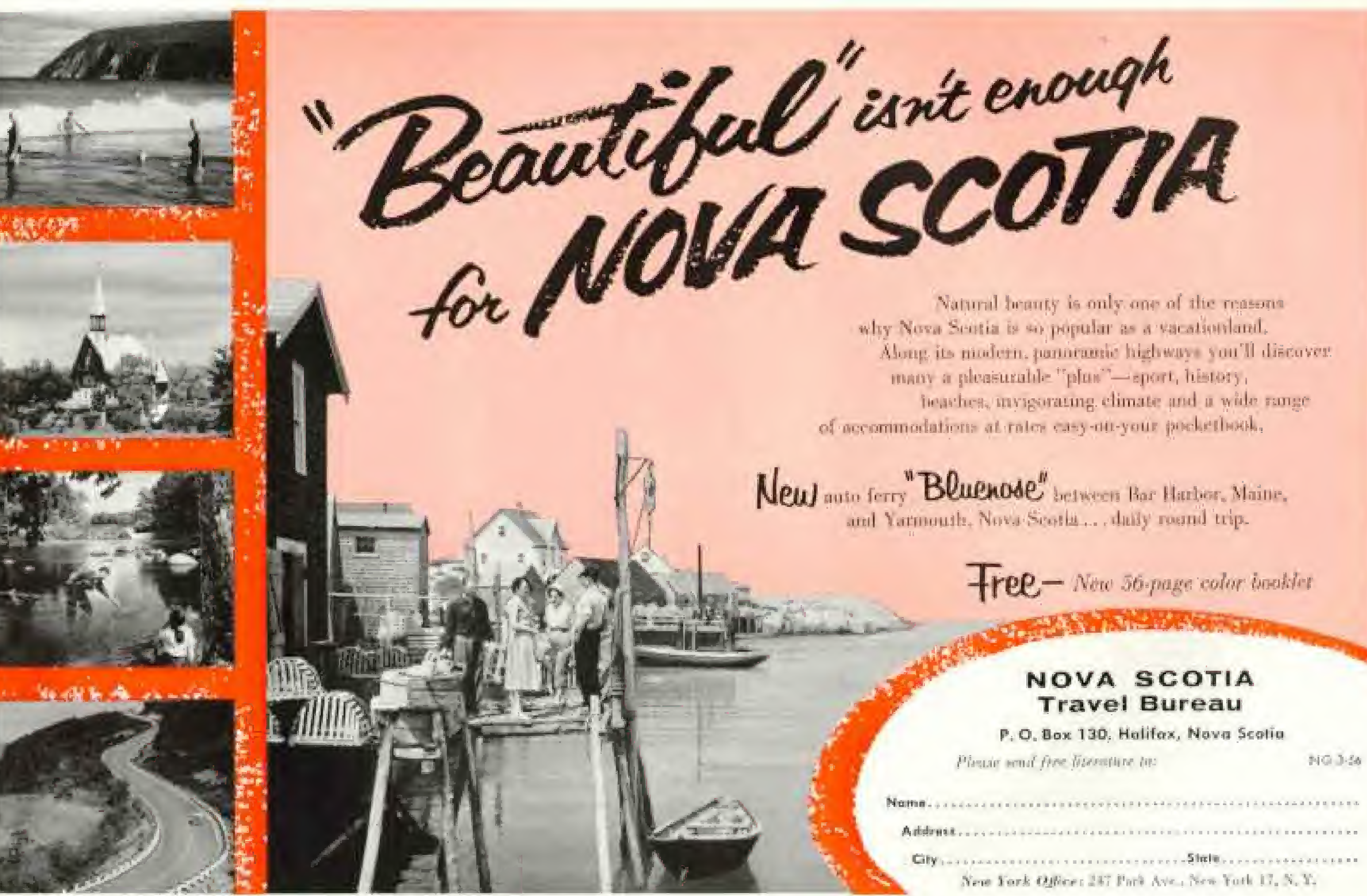
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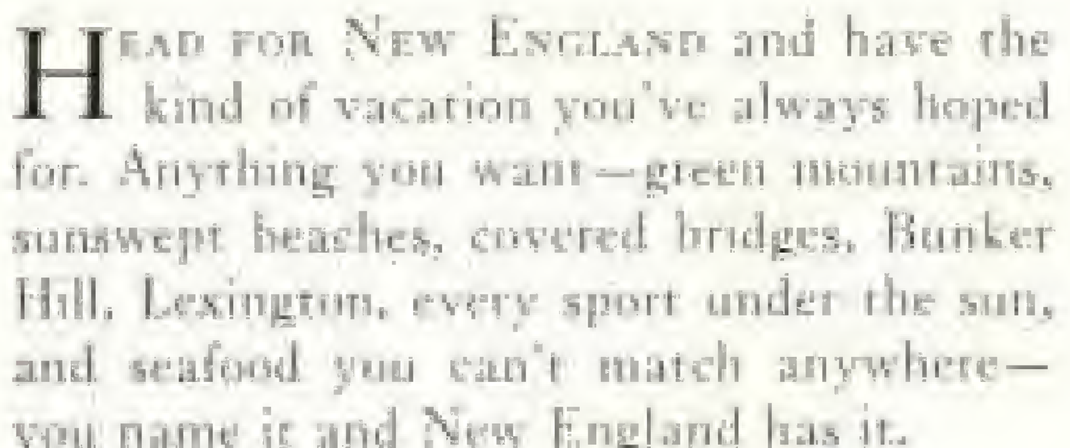

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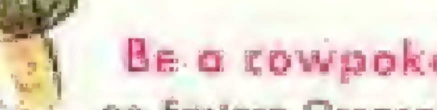

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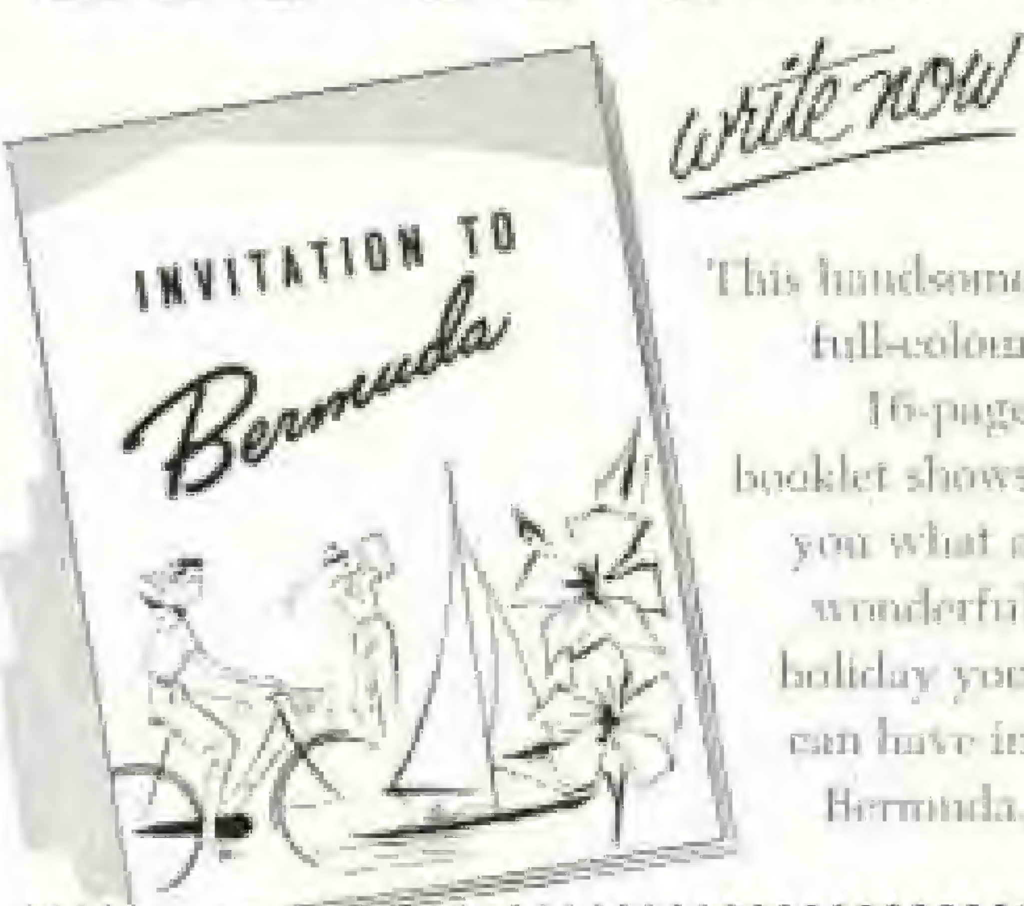

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Adults should also see the dentist regularly . . . at least twice a year. His examination, including X-ray studies when necessary, can reveal hidden trouble. If unhealthy conditions of the teeth and gums are not treated early, they may lead to premature loss of teeth.

Many dental procedures have been vastly improved. Even the dental drill has been modernized and making and fitting bridges and dentures has become such a fine art that wearers soon cease to be conscious of them.

Preserving the teeth and gums also depends largely on good daily care, including regular brushing and proper diet. In fact, good daily care, coupled with regular dental check-ups, can greatly increase the chances of keeping most of one's teeth throughout life.

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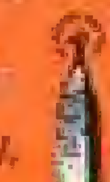
Insurance  **Company**

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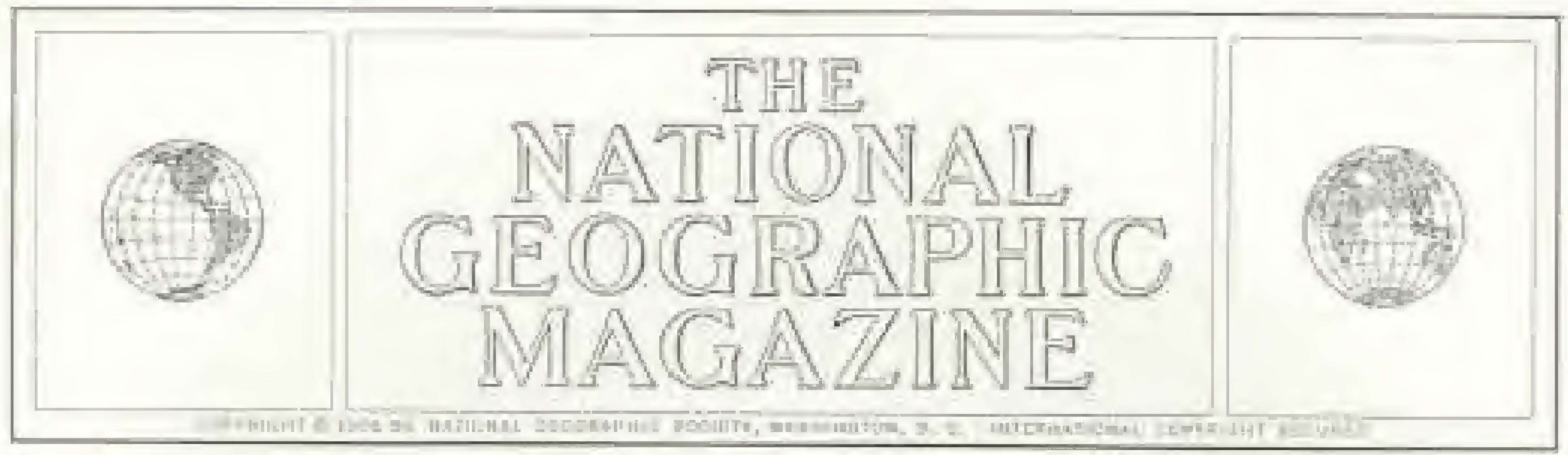

High Road in the Pyrenees

Medieval Towns and Geographic Oddities Hide in the Rugged Range That Forms the Frontier Between France and Spain

BY H. V. MORTON

With Illustrations from Photographs by Justin Locke

THE road led skyward across the bald summits of the mountains, then looped downward into a green valley where pine trees climbed the slopes and a river glided over boulders. I came to a town whose balconied houses nodded together in the dust of centuries, and I looked around for a garage.

A Spaniard who apparently had been rolling in oil emerged to work a hand pump. A herd of goats trotted past in almost knee-high dust, and then I noticed the civil guard. He had appeared silently from nowhere, as these guardians do, and was casually leaning on his carbine, watching. The sun glinted on the black patent leather of his Napoleonic hat, the dust lay thickly upon his black boots, and this was not the day he shaved.

The guard's eyes moved carefully over me and lingered on the car; tourists rarely come to the Spanish side of the Pyrenees. But are there not smugglers and other questionable characters who hide out on the French border and come down into Spain on evil missions?

Burning with personal curiosity and professional how-come, the guard inquired conversationally, "The senor is an *americano?*"

"No, senor—*ingles.*"

Then I decided to ease his mind.

"I have come from Barcelona and am going to motor along the Pyrenees to the Atlantic. Perhaps I shall then cross into France and look at the mountains from the other side."

He nodded solemnly and said, "*Bueno.*" (He would now be able to tell them all about me at the cafe.)

I continued my journey with the memory of a smart salute and of dark eyes charged with wonder and amusement at the thought that these Americans or English—for what real difference is there between these crazy folk?—should go tearing about the world when, obviously, they have enough money to sit comfortably at a cafe in Barcelona and admire the passing senoritas.

Old Spanish Town in France

I had traveled north from Barcelona to the Franco-Spanish frontier at Puigcerdá, where one of the four railways that cross the Pyrenees comes snaking through the mountains from France. And now I encountered one of the oddities of the Pyrenees—the Spanish town of Llivia *in France!*

No one asked to see my passport when I crossed the border and took a road that led to a little village that could not have been

---

The Author

More than 25 books have made the English travel writer Henry Vollam Morton known to millions throughout the world. Among them are *In Search of England, In the Steps of the Master, Through Lands of the Bible*, and, most recently, *A Stranger in Spain*. He made his NATIONAL GEOGRAPHIC debut with his memorable "In the London of the New Queen," in the September, 1953, issue.

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Sheep Roam Above Valle de Arazas, a Natural Fortress in the Spanish Pyrenees

In medieval times Christian knights held this remote valley against Moors. Here they launched the reconquest of Spain. Brèche de Roland, a pass beyond the horizon, calls to mind the legend that the hero Roland cleft the mountain with his magic sword while fighting a desperate rear-guard action for Charlemagne.

Each Summer Aragon Shepherds Lead Their Flocks up into the Clouds

These young herders sleep in caves used by men from a time beyond memory. Their Churro sheep, recently sheared, yield meat, milk, and a coarse fleece called "mattress wool." Autumn snows will drive the flock down to the lower valley. Much of the range is included in the National Park of Ordesa, which Spain created in 1918.

more Spanish: ancient brown houses with iron balconies, a huge church with a bell that sounded like a cracked bucket, a Spanish post office, and the red-and-yellow flag of Spain flying from the police station. Yet the town is territorially in France (map, page 308).

"Our history is indeed singular," explained the *alcalde* (mayor) as we sat talking outside the little cafe. "In 1659 some Spanish villages in the upper Cerdagne were handed over to France to straighten out the frontier. At the last moment Llivia, although only a small place, recollected that centuries ago she had been the proud capital of the Roman Cerdagne. Was she now to be classified as a mere village? Was the past to be insulted?

"In the face of Llivia's pride the international lawyers could do nothing, and we were excluded from the ceded territory. Instead, a neutral road was built to connect us with Spain, and here for the last 300 years we have remained, a Spanish island in France."

Bishop Collects Feudal Tribute

Motoring on, I came at length to a medieval town in full working order. From the old walls leaned iron braziers that, when filled with pitch and wood, lit the streets centuries ago. By day the narrow sidewalks are crowded with old women in black selling ducks, geese, and chickens, red and green peppers, figs and peaches; by night silence enfolds the streets which then become the perfect background for feuds of the Montagues and Capulets. This is Seo de Urgel, seat of the Prince Bishop who is co-ruler with the President of France of the 175-square-mile mountain principality of Andorra.

Every year the 24 members of the Council of the Valleys of Andorra descend from their mountains and arrive in solemn state at Seo to pay their feudal tribute to the Bishop—6 hams, 6 cheeses, 12 hens, and 460 pesetas, about $42.00.

Even so, the Prince Bishop comes off better these days than the French President, whose rent money, rated in the Middle Ages, now amounts to less than $2.80.

Andorra Welcomes Holidaymakers

From Seo I drove half a dozen miles to the frontier of Andorra. This tiny country welcomes more tourists every year.* Fortunes made in Andorra during World War II are now being invested in modern hotels. Shops are still full of duty-free nylons, French scent, brandy, wines, and every conceivable brand of English and American cigarettes at bargain prices.

French tourists pile into Andorra every day in motor coaches from Ax les Thermes and return in the evening loaded with parcels. Frenchwomen go to Andorra to buy handmade Spanish patent-leather shoes and handbags; Frenchmen buy made-to-measure suits at a fraction of the cost in France.

Even a few years ago the name Andorra suggested smugglers, but today it suggests the words "*Aqui! Radio Andorra!*" uttered in ringing tones which pursue the traveler all over Europe. The station, one of the highest in Europe, stands 4,000 feet up in the mountains.

Worlds apart from the chromium-plated Andorra of today is the farmer off the main road who still grows his tobacco crop and drapes the leaves from every balcony, and his wife who washes clothes in a hollowed-out tree trunk. They belong to an older world (page 334).

Leaving the fascinating frontier of the eastern Pyrenees behind, I traveled westward into a solitude of barren mountains. They reminded me of Africa when I saw their arid starkness, scorched by the sun.

Rugged Mountains Balk Road Builders

You may be fairly sure that when anyone mentions the Pyrenees he means the French Pyrenees, a tourist haunt for years. The reason is that the French roads are first class. The Frenchman sees a range of mountains that drops steeply to the plains. Beautiful streams descend through their valleys to swell the fair rivers of France. It was not too difficult for the French to drive their magnificent Route des Pyrénées through this sort of country (pages 312 and 332).

But the Spaniard sees a different picture. On the south the mountains rise in complex, rugged ranges in successive lines parallel with the main axis of the chain. This belt of foothills, sometimes 60 miles in depth, has largely defeated the road builder, and there are enormous areas of the Spanish Pyrenees which are best seen by a man on a mule.

A Spanish Route des Pyrénées has often been contemplated by Spanish Governments,

*See, in the National Geographic Magazine: "Incredible Andorra," by Lawrence L. Klingman, August, 1949; and "Andorra—Mountain Museum of Feudal Europe," by Lawrence A. Fernsworth, October, 1933.

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France's Highest Waterfall Drops 1,385 Feet Down the Cirque de Gavarnie

Rock-grinding glaciers fashioned this amphitheater, Victor Hugo's "Colosseum of Nature." Pic du Marboré (left) and the three Pics de la Cascade fill the horizon. These guides pause a third of the way to the top.

Fashion Stands Still → in Ansó, Spain

Older residents cling to ancestral garb in this canyon-walled Aragon village.

Men wear baggy black breeches over white bloomers. Yard-wide sashes drape the hips. Round hats are anchored by kerchief liners, and rope-soled sandals are held with cords.

Not a nun, the woman wears the regional costume. Her dark cowl conceals the high-waisted pleats of a woolen gown.

Ansó's fiesta dress shows on page 329.

← A French shepherd in the Vallée de Campan uses his knapsack to carry a lamb to market.

but has always been shelved because of the expense and the appalling engineering difficulties. I was sometimes shocked to discover that I had motored 200 miles to reach a place 30 miles away as the crow flies! On the other hand I was astonished by the excellence of those roads that do exist.

Rain in France; Spain Parches

Another fundamental difference between the French and the Spanish Pyrenees was explained to me as I traveled through the exquisite valley of the Segre. Suddenly the figure of an excited Spaniard waving a red flag enlivened the lonely road.

I pulled up, and he explained that "dinamiteros" were at work near by. In a moment there was a loud explosion, and I drove on into an astonishing scene.

In this valley, miles from anywhere, men swarmed over a colossal excavation that looked like the dry dock for a dozen battleships. Concrete mixers rumbled, snorting bulldozers advanced and retreated from the edge of an abyss, and a light railway rattled through the dust. Yet another hydroelectric dam was rising.

Making electricity from harnessed rivers is the one big industry of the Pyrenees. The hydroelectric boom began early in this century with the work of Dr. Fred Stark Pearson, an American engineer who perished in the sinking of the *Lusitania* in World War I. He designed the water supply of the river Noguera Pallaresa. Today there are dozens of generating stations in the Spanish Pyrenees, and one-fifth of Spain's electricity comes from these mountains, I was told.

A new dam, which I saw in the making, will be able to produce 40,000 horsepower. The engineer who showed me over this impressive construction concluded our tour with a question.

"Do you know the difference between the French and the Spanish side of these mountains?" he asked.

Then, without awaiting my reply, he said: "Rainfall."

"That is the fundamental difference," he continued. "The French Pyrenees get rain and the Spanish do not. Across the border there is water to spare, but here, in spite of all our planning, the reservoirs are never sufficient to make up for the periodic droughts. Nature has not been fair to Spain!"

The mountains themselves are partly responsible, wringing the northwest winds dry before they leave France. Winter "highs," as the meteorologists call them, finish the job by deflecting the winds that bring other Mediterranean countries their best rainfalls.

Majestic Wilderness Awaits Roads

I now entered a wilderness of incredible beauty and majesty, several hundred square miles of mountains, valleys, lakes, and rivers that are one of the glories of Europe. The few roads which exist there touch only the fringe of the tract, and to see this part of Spain properly one would have to be on foot or muleback.

The villages are far apart and often grouped around a hill on whose summit stand the ruins of an old castle; the modern world made no impact here at all until the coming of the motorbus. A few dusty and asthmatic vehicles link the district with the towns of the southern plain, but they leave the heart of it undiscovered.

This is the country that lies between the main road from Puigcerdà south to Barcelona and the road over the Somport south to Jaca-Huesca-Zaragoza.

Toward evening I approached the terrible bends and gradients of the pass over the Maladeta—the Accursed—massif where warning

Farmers in Jaunty Berets Sell Pigs in Graus

Visitors to Spain must accommodate their appetites to a new timetable. Breakfast—rarely more than chocolate and doughnutlike *churros*—comes at 8 o'clock. Lunch is served about 2 p.m. and dinner from 10 p.m. to midnight. Spaniards fill the long gaps between with tidbits of fried shrimp, ham, and cheese.

Each Iberian region, says the author, suggests a new restaurant with its favorite dishes unlike those of any other. Pork, however, is a specialty of the entire land.

These Aragon-bred pigs are sold on the hoof as a guarantee of freshness. The smallest will be roasted whole as a dish called *tostón*. Baked with an apple in its mouth and with garlic, pepper, onion, and sausage stuffing in its belly, tostón makes the traditional feast of All Saints' Day in November. Cooks delight in proving the tenderness of the pork by carving with the edge of a plate.

Spanish Onions Drape a Human Showcase

Although brown, barren hills stretch over much of Aragon, the river valleys grow lush with wheat, orchards, and vegetable gardens.

After the harvest, Spanish housewives buy all the onions and garlic needed for the year.

These mild yellow onions are esteemed for sandwiches and salads half the world over.

The vendor stands in one of the arcades encircling the plaza of Graus (opposite).

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Mounds of Onions, Garlic, and Peppers Tempt Shoppers in the Graus Market

The Pyrenees: a Mountain World of Diverse Peoples and Languages

road signs said in Spanish: "Road Dangerous," and "Many Precautions." It began to grow dark as I ascended into mist.

Had there been anywhere to stay the night, I would gladly have called it a day rather than face the Bonaigua Pass at that hour. But there was nothing to do but go ahead, over the 6,800-foot pass which crosses the main watershed of the Pyrenees. My view downward through rents in the mist was terrifying, and every corner revealed new and threatening ridges and peaks.

I came into Viella after dark and saw a shaggy mountain town with a river rushing through its middle. Occasional lamps shed pools of light at street corners, men led mules over the cobbles, and I could feel the chilly presence of great mountains all around me.

The little inn proved a warm haven of light and laughter. It was full of Barcelona people returning from a bus trip to Paris. They sat at long tables in the dining room with napkins tucked into their collars, sipping sharp red wine and merrily recounting their experiences in the gay city. What a marvelous sight they were after the Bonaigua Pass!

Pic de Aneto Tops the Pyrenees

In the morning I looked out upon the wonderful Valle de Arán, where apples were ripening in the orchards and the sound of the church bells came down on the wind from brown villages perched on the steep mountain slopes. To the south rose the majestic peaks of the Maladeta, capped by the highest mountain in the Pyrenees, the Pic de Aneto (11,168 feet). To the north a good road climbs over into France.

Most people, I think, imagine the Pyrenees a single line of mountains, but this is not so. They are really two ranges, one starting from the Atlantic and the other from the Mediterranean. They miss each other by about 10 miles in the center, and this gap is the Valley of Aran.

Just as Llivia is a piece of Spain in France, the valley is a bit of France in Spain. It thrusts itself to the north and, though geographically French, is politically Spanish. Its only connection with Spain is the Bonaigua Pass, open only four months a year.

So for eight months out of twelve, the valley and its capital, Viella, do all their business with France. Most remarkable of all, the pretty river that runs through Spanish Viella is the French Garonne, gathering strength and size in its northward journey from its source in Spain.

"Most of us speak French here," said the mayor, "though we are Catalans."

He then told me a story which, taken with

that of the mayor of Llivia, suggests that when the Treaty of the Pyrenees was drawn up in 1659, the Spaniards considerably outsmarted the French.

"Everyone expected that the Valle de Arán would be handed over to France," he said, "but some cunning Spaniard mentioned casually to the French negotiators, 'Of course you regard the valley as Spanish?' Not wishing to admit that they didn't know where it was, the French replied 'Of course,' and the Valle de Arán remained Spanish!"

Green Dye Shows Source of River

People in Viella still remember vividly the startling day in 1931 when the Garonne suddenly turned a vivid green color. There was talk of magic and witchcraft until the news came through that the French speleologist Norbert Casteret had dumped 120 pounds of fluorescein into the Hole of the Bull on the slopes of Pic de Aneto. Thus he proved for the first time that the true source of France's famous river is among the glaciers of this Spanish mountain.

This was far more than an interesting experiment. It caused the French Government to persuade the Spanish Government to abandon a hydroelectric scheme which would have reduced the flow of the Garonne by half and caused consternation among the farmers and industrialists of southern France.

The Pyrenees illustrate perfectly the regional character of Spain; the eastern Pyrenees are Catalan, the central are Aragonese, and the western are Basque. Though technically Spaniards, the people of the mountains have more in common with the French over the border than with such fellow Spaniards as Gallegans or Andalusians.

The frontier, such a formidable obstacle to the tourist, is to these mountain folk only a line on the map. They cross into France and back into Spain by unfrequented tracks and, if caught with contraband, can always say they are bringing back a present from a sweetheart or an aunt!

One of the highest spots in the Spanish Pyrenees is the National Park of Ordesa. It is 45 miles as the crow flies from Viella, but

I arrived there late one afternoon after journeying more than 260 miles as the motor car rolls. Huge mountains overlook a shelf of rock on which the Spanish Government has built a comfortable little hotel called, I think too modestly, a *refugio*.

The week I spent there was a time of sheer enchantment. The park is 20 square miles of wild country enclosed in a canyon that, I am told, bears some comparison with the more famous one in Arizona. The high mountains of the Pyrenees rise all around, and on the other side of them, in France, is the famous Cirque de Gavarnie (page 303). Mountaineers often climb over from Gavarnie, spend a night at the refugio, and return the next day.

The charm of Ordesa is the perfect peace of a landscape that remains as it was when it left the hands of its Maker. Visitors go into the mountains with cameras to hunt the *sarrio*, the shy Pyrenean chamois, or the equally shy *bucardo*, the Spanish mountain goat. Those who climb high enough return with a sprig of the famous alpine edelweiss, known in that part of the Pyrenees as *pie de león*, lion foot.

Guests returning to the refugio are greeted by a splendid and friendly specimen of the by no means common Great Pyrenees dog, a breed that combines size and formidable appearance with a devoted attachment to man. A Pyrenean belief is that ages ago Spanish monks took some of these affectionate creatures to Switzerland, and that the famous St. Bernard breed is the result.*

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← Lourdes: a Monument to the Faith of a French Shepherd Girl

Ninety-eight years ago young Bernadette Soubirous saw in a grotto (beyond the wall at right) a vision of a "Lady." Day after day the child returned, and so did the apparition.

The Lady proclaimed herself "the Immaculate Conception"—Mother of Christ. "Tell the priests they must build a chapel," she commanded, and these sanctuaries rose before the end of the 19th century. She bade that processions visit the spot; today two million pilgrims a year attend such spectacles.

Bernadette's Lady asked the child to dig for a spring in the grotto and to drink and bathe in its waters. Since that time the halt and the ill have streamed to Lourdes by the tens of thousands. Many have reported cures.

These nurses in the Esplanade des Processions face the Church of the Rosary. Staircases to the roof of the low twin-spired church lead to the loftier Basilica. Mont du Calvaire rises on the left.

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I find it difficult to believe the dog fancier who told me that these playful creatures were dressed in armor centuries ago and sent into battle to stampede horses and attack the enemy. Hardly more credible is the thought that they were once employed to guard sheep against wolves and bears. If this is true, an extraordinary sweetness of character must have come over the breed in recent times.

This animal must not be confused with the Pyrenean sheep dog, a smaller, sharper, less aristocratic character of great intelligence that is taught by the shepherds to obey signs, whistles, and even whispers.

As I drove away down into the valley, I remembered the amazing sunsets at Ordesa—how the valley would grow dark below while the peaks above still glowed golden with the sun. Then gradually the light would pass upward until only the highest peaks were lit, then the light would slide off into space and the stars would be burning in the sky.

Spa Boasts Wagnerian Scenery

The Pyrenees are perhaps Nature's largest mineral water factory. The mountains, so apparently solid, are actually catacombed with rivers and lakes and with springs which shoot up everywhere, charged with every conceivable combination of minerals, a fact well known to the ancient Romans.

On the Spanish side hydropathic possibilities have not been exploited as in France, where every other place is a spa, but a short run from Ordesa is the fashionable Spanish spa, Balneario de Panticosa. Here radioactive waters gush out of the mountains.

The site of this spa is fantastic. A cluster of large hotels; shops, a post office, and an assembly room where a string orchestra plays in the evening stand in a slice of scenery that looks like an overture by Wagner. The buildings are more than 5,300 feet above sea level. Behind them a tawny wall of mountains rises another 4,000 feet, so steeply that avalanches make a winter season impossible, or at least unwise. But until the snows come, the spa is an incredible scene of sophistication in the wilderness.

Spanish society may be seen here from June to September, with an occasional English peer, Italian counts, Portuguese industrialists, and others enjoying the mild derangements of

* See "Working Dogs of the World," by Freeman Lloyd, NATIONAL GEOGRAPHIC MAGAZINE, December, 1941.

Heads in Clouds, Feet in Snow, Climbers Scale Monte Perdido

In the heart of the Spanish Pyrenees, Monte Perdido rises 10,997 feet, third highest point in the range. Though its name means "lost," Perdido may easily be found by anyone with stout legs and a guide.

Jutting Pic du Marboré (right) shelters the Cirque de Gavarnie in France (page 303).

Page 313, lower: Autumn's first snow clogs the corkscrew road near the top of Pic du Midi de Bigorre. Springing from a plain to a towering 9,439 feet, Pic du Midi looked so high that many used to regard it as the summit of Europe.

In 1787 Ramond de Carbonnières, a French geologist, became the first to ascend Midi's crest, and saw the glaciers of the Cirque de Gavarnie on the horizon above him. Thus he established Midi as a lower peak.

Route des Pyrénées Scrapes the Sky

France opened this sea-to-sea road about the turn of the century. Skirting the main crest, it crosses passes over ridges that extend like bent fingers (page 333). Here at 5,610 feet the route threads the Col d'Aubisque. Argelès Gazost, 19 miles from the marker, and Eaux Bonnes, 7½ miles, offer thermal spas.

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the digestive system that brought them to the spa.

There was some excitement when I was there. Workmen repairing one of the warm springs discovered a number of Roman coins.

Roman Coins of Crucifixion Time

When we brushed off the corrosion, we read with a feeling of awe the letters "TI CAESAR DIVI AUG F AUGUSTUS . . .," the superscription of Tiberius Caesar who ruled the Roman world at the time of the Crucifixion. In English, this means "Tiberius Caesar Augustus, son of the Divine Augustus."

I was introduced to the Madrid banker and industrialist Don Alfonso Urquijo, and his nephew, Don Jaimé Urquijo, who had come to Balneario de Panticosa to shoot chamois.

The nephew's passion is the creation of double hybrid maize. He has grown various types of corn for different regions of Spain. He told me he is slowly conquering the conservatism of the Spanish farmer. In Spain corn is used chiefly as animal feed; new varieties vary from huge white cobs to small red ones (page 316).

Don Alfonso asked me to dine with him, and chamois steak *en casserole* was the chief dish. The meat was stewed in red wine and herbs and was delicious, a blend of Canterbury lamb and the springbok venison eaten in South Africa.

"No one on earth is more independent than the Aragonese mountaineers," said Don Alfonso. "They are proud—and also very touchy. Behind them are long centuries of isolation in one little valley, which they regard as the center of the world.

"Some of these valleys are still self-contained communities, where the regional dress is worn and old customs observed. When you go to Jaca, you must go to the valley of Ansó and look at the Aragonese costumes worn there. The people dislike strangers and cameras, because they think they are being made fun of, but I will give you a letter to the mayor of Ansó that will smooth the way."

Soldiers, Girls—But Few Dates

In a few days I found myself in the beautiful old town of Jaca, with its superb cathedral. My room overlooked the narrow main street. I had been so long in the mountains that this little town of some 9,000 inhabitants seemed like a metropolis.

From my ironwork balcony I looked down with delight on the street, crowded by day with rattling mule carts and wagons and at night with the scene of the *paseo*. Then hundreds of young conscripts from the local barracks, in creased khaki and white cotton gloves, marched up and down, passing and repassing the glossy-haired senoritas. Rarely did they overstep the rigid bounds of Spanish decorum by stopping to make a date.

From Jaca I made several excursions, the first to the famous Somport Pass, where both road and railway cross into France. Unlike many Alpine passes, those in the Pyrenees are all high except, of course, at the seaward extremities. The Somport is 5,351 feet high, and rarely is it possible to take a car over it between November and June. It is a most historic Pyrenean pass, for it was the old Roman road into Spain, and it was also across the Somport that Moorish armies marched in 732 when they invaded France.

The road, after running through Canfranc, begins to climb into a bleak, treeless solitude where the brown hills are folded against one another and the road twists and turns like a piece of gray tape. Near the top, tall poles on each side of the road are markers to define it during the winter snows.

Not far from the summit of the pass is an enormous, and in that spot preposterous, structure, the International Station, where French trains come through the five-mile Somport tunnel into Spain. It is a huge crystal palace of a place and at that altitude a major architectural achievement. Half the station is French, half Spanish; on one side is French rolling stock, on the other Spanish.

There was not a sound in all that huge expanse of glass, track, sheds, waiting rooms, and platforms. It was like the palace of some sleeping ogre. The place awakens only when the international expresses arrive.

Town Elders Ignore Strangers

On another day I visited Ansó and tried out Don Alfonso's letter on the mayor. As I approached a huddle of ancient stone houses on a hilltop, I saw an old man by the roadside. He wore baggy black knee breeches slit to reveal a pair of white bloomers beneath. His stockings were of white cotton, his shoes were rope-soled, he wore a sleeveless waistcoat, and around his waist was a yard-wide purple sash. His hat, worn over a black head scarf, was the low-crowned bowler as made famous by Charlie Chaplin.

Albert E. Lamarsal, Jr.

Solar Furnace in the Pyrenees Creates Heat of 6,000° F. and Melts the Hardest Metals

France traps solar power at Mont Louis because the sun there shines nearly 300 days a year. This 35-foot reflector catches rays from a flat mirror that tracks the sun automatically. Its 3,500 pieces of glass bend the beams to a blistering focal point, leaving no waste products as in chemical combustion. The process promises production of high-temperature materials such as refractory linings for steel furnaces.

← Trees in Palamós Bear Strange Fruit

Corn, or maize, a native of the Americas, was introduced to Spain by Christopher Columbus.

This farmer dries his corn crop beyond reach of rodents. Ears are hung by the shucks in September and allowed to weather into November.

Having little taste for corn dishes, Catalans feed this crop to their cattle.

Ripening Tomatoes → Hang from Beams

Page 317: Gardeners at Torroella de Montgri cultivate another immigrant from the New World. Picked green, the tomatoes ripen slowly while dangling from the ceiling. If left undisturbed, they remain edible for 10 months. Very ripe tomatoes smeared on bread doused in olive oil make a popular Catalan sandwich.

The photographer saw 400 pounds of the fruit stored in this room.

Catalan Farmers Ankle-deep in Mud Cut Rice and Tie Sheaves

Spain's Costa Brava—the "wild coast"—in the shadow of the eastern Pyrenees, composes a small world set apart by poor communications. The people cultivate lands settled by ancient Iberians, Phoenicians, Greeks, and Romans and pillaged by Visigoths, Normans, Saracens, and Barbary pirates. Self-reliant, they harvest within sight of their homes most of the food they need.

For generations Costa Bravans have grown rice in the pockets and coastal marshes of a hilly land. In recent years production has increased to such an extent that Spain exports her excess to Japan.

Catalans cook the cereal with fish, lobster, shrimp, mollusk, crab, eel, or squid, all taken fresh from the Mediterranean Sea at their front door. The result is a *paella*, justly famed abroad.

These farmers live near La Escala, chief fishing village of the region.

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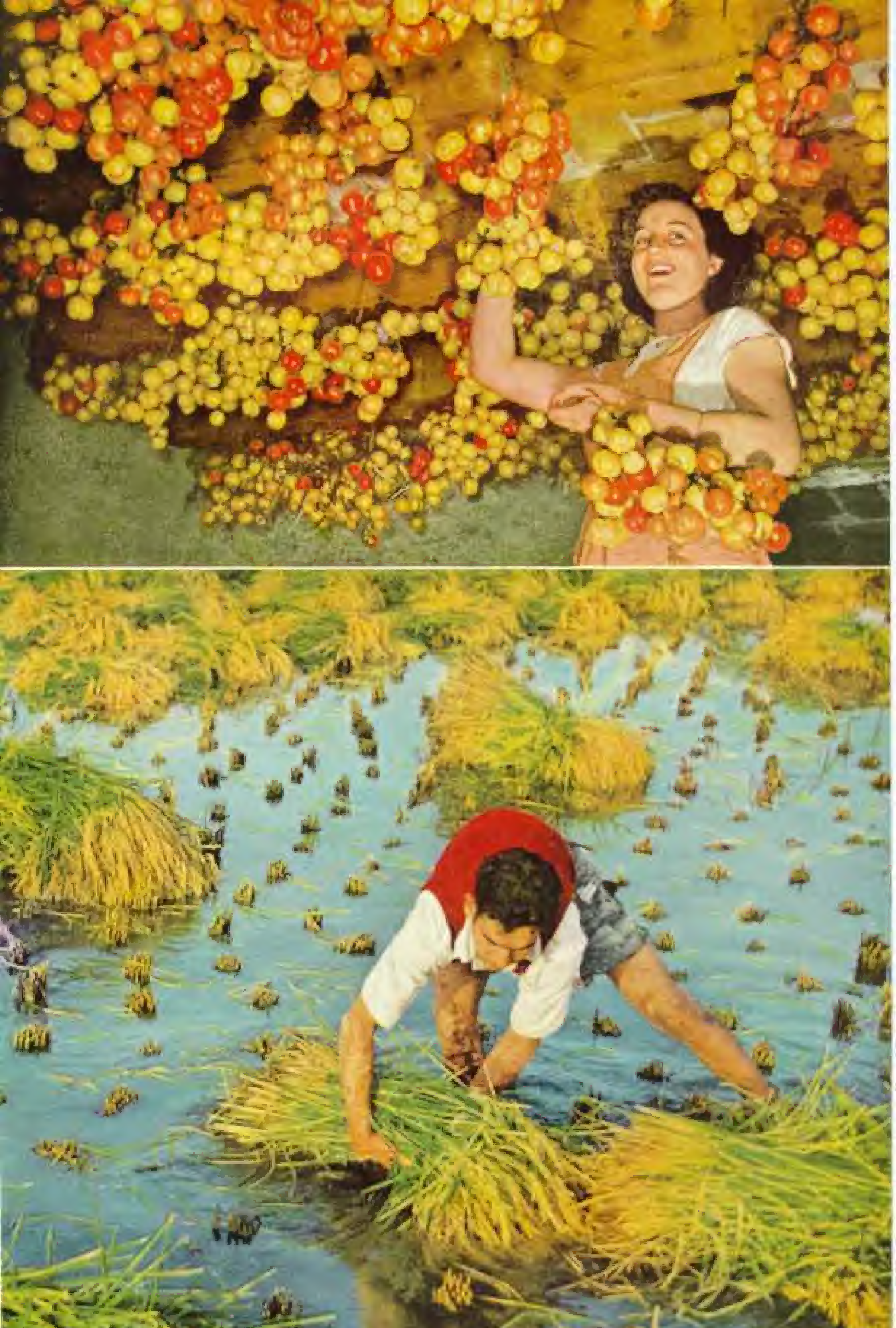

The moment he saw me, this man deliberately turned his back and walked away.

The town was a warren of narrow streets. I saw many old men dressed like the man on the hill, but they all vanished at the sight of me; one, who was feeding his hens, suddenly threw a bowl of corn at them in his haste to get away. He retreated, banging his door after him. The young men, the women, and the girls were all in ordinary clothes.

The town hall stood in a tiny plaza, and the mayor, a typical shrewd Aragonese farmer, sat in his parlor wearing the Ansó dress. He read Don Alfonso's letter and said gravely, in the polite Spanish formula, that the town belonged to himself no longer, but to me.

"This is the old costume of our valley," he said. "About 50 of us, the oldest and best known, wear it every day. The young men wear it only at fiestas, for it is not a convenient working dress, and it is also expensive. At any rate, it is a distinction, and we older ones are proud of it."

When I asked the mayor if I could see some of the women in their festive dress, he smiled.

"It takes a woman of Ansó about two weeks to dress for a fiesta," he said. "First, the clothes have to be taken out of the chest in which they are kept. Then they have to be washed, ironed, and starched. Some parts have to be pleated. Then there is the jewelry to clean. Then there is the hair! Nevertheless, I will see if I can persuade some of them to dress for you, but it will not be easy."

Rhythm and Old Pageantry

I lunched at the local inn, where for the first time I tasted a rural Aragonese dish called *migas*—fried breadcrumbs, ham, and onions eaten scalding hot with a wooden spoon.

Afterward I sat in the little plaza. I was thinking that I was right out of the world, away back in the Middle Ages, when high above from an open window sounded a female announcer's voice: "*Aqui! Radio Andorra!*" followed by a burst of hot rhythm!

Then, to the sound of Billy Somebody and his Boys, came a scene from the Middle Ages. Stepping gravely over the cobbles, the mayor approached, and on each side of him walked a young woman dressed in the spectacular costume of Ansó (page 329).

The women are a great deal gayer than the men in their dress. A long pleated gown of green serge made on local looms is worn over a white linen undergarment with puff sleeves and a collar that rises at the back in a ruff. Across the breast are bands of red and yellow ribbon to which is attached a small framed icon of the Virgin Mary.

Elaborate gold earrings, a gold crucifix pendent from a brooch, and two little gold images of the Virgin of the Pillar of Zaragoza, patron saint of Aragon, complete the jewelry. The dark detachable sleeves, which are drawn on like long gloves, are characteristic of the costume of the Middle Ages. So, I thought, were the hats: one girl wore a red toque, and the other a kind of turban.

"This is the dress they wear for weddings and fiestas," said the mayor. "You must come someday and see all the women of Ansó dressed as splendidly."

The girls laughed and said they did not feel very splendid, for their clothes had not been taken out of the chest since the feast of St. Veronica.

I solved the mystery of the outsize chimneys seen all over the Aragonese mountains. Entering a house notable for one of these chimneys, the mayor showed me that it was the outlet for a central hearth, a room within a room, where during the winter the family gathers to sleep around the log fire.

My departure from Ansó was in pleasant contrast to all the back-turning when I arrived. The girls smiled and waved, the dogs barked, and the mayor, bowing gravely like a grandee, bade me farewell and told me to hasten my return.

(Continued on page 324)

Boats Carry Lanterns to Lure Fish into Nets at Night →

Page 319: Small craft go fishing in groups of 30 to 50. Seen from the shore at night, their lights shimmering across the sea, they have the look of a small village riding on the water.

These women mend nets at Tossa, a village of antique charm cherished by vacationers, writers, and artists.

Banyuls Wine Ages in Carboys Under the Mediterranean Sun →

Where the French Pyrenees meet the sea, vines of the Grenache grape climb to the very summits of the mountains. Here, near Banyuls, vintners produce a sweet, tawny aperitif.

Bared to the almost constant sun, wine in these bottles sweetens to correct taste in three months. A roof of wire netting discourages unauthorized tasters.

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Kodachrome by Walter Meayers Edwards, National Geographic Staff

Seen from a Plane, the French Pyrenees Present a Desolation to Match Antarctica's

Route des Pyrénées appears as a snaky line twisting up Col du Tourmalet, the snow-covered saddle at center. Skiers flock to this area in winter. One of their favorite resorts lies hidden beyond the col.

Pic du Midi de Bigorre Sector Erects a High and Icy Barricade Between Nations

The Pyrenees' rugged appearance proclaims their youth; weathering has not yet worn them down. Early snows blocked the author from visiting the observatory near the summit of 9,439-foot Pic du Midi (right).

The Eaves of the Pyrenees Shelter Panticosa, Spain →

Hundreds of medicinal springs flow from the rocks in this range; some of the best-known dispense sulphur water. Highest spa in the Pyrenees, Balneario de Panticosa stands at 5,377 feet. Roman coins unearthed at the springs prove the resort was popular in the first century.

Visitors sometimes catch a glimpse of the shy, agile Pyrenees chamois, which abound here. In summer, the goatlike antelopes climb the highest cliffs. Some fall to hunters equipped with binoculars and rifles with telescopic sights.

← The Encantats: Spain's Hills of Enchantment

Catalan mountain climbers and campers make a playground of these jagged peaks. In the words of the French-born English writer Hilaire Belloc, a "sense of an unquiet mystery" pervades the region.

Medicinal springs at near-by Caldas de Bohi yield some 30 different kinds of mineral water, ranging in temperature from 39 to 125 degrees F.

Straw Mountains Stand → Peak to Peak in Navarra

Page 323. Spanish farmers near Artajona load carts with bedding for their cattle. Stacks rise 50 to 75 feet.

© National Geographic Society

Treed! Amateur Bullfighters Risk Horned Death in Bayonne, France

Each August townsmen set fighting bulls free to roam the streets. Young daredevils prove their courage by exposing themselves as moving targets. Basques especially delight in this dangerous sport.

In a few days' time I stood on the Franco-Spanish frontier at Irún, near the Atlantic coast. I had traveled through the Basque Pyrenees, where the mountains are lower and the landscape less turbulent, to San Sebastián, the most beautiful watering place in the north of Spain. Now the Spanish police were waving me over the international bridge, at the far end of which I could see the French gendarmes in their short blue coats and visored caps.

Author Enters a Greener France

The country I entered was soft, gentle, and green. I realized how brown Spain is and again remembered the engineer who envied France her Pyrenean rainfall. The contrast is startling. The heights of the western Pyrenees, which rose everywhere, were nowhere hard or savage, but gentle, softly curved, and undulating.

How different, too, were the common scenes of life, the people and their homes, from those in Spain. The cream-washed towns and villages through which I passed, each one with its *pelota* court, stood among kitchen gardens. Slow, swaying oxcarts came along the road piled with bracken from the hills, the oxen wearing caps of tasseled sheepskin. Beside each cart paced a grave, impassive Basque crowned by that insignia of Basquedom, a black beret.* Shepherds in the hills, each with an umbrella slung across his back and an alert sheep dog at his feet, stood leaning on their sticks.

Another remarkable difference between the French and Spanish Pyrenees is the presence of the tourist. For years the Route des Pyrénées has offered easy access to the exquisite valleys and the mountains. Motor coaches run everywhere, and there are daily trips to all main points of interest. In the most remote fastnesses of the French Pyrenees you are likely to come upon visitors sitting beneath the striped awning of a little restaurant or under gay-colored beach umbrellas.

I stayed the night at St. Jean Pied de Port, a little town which, as the name implies, sits at the foot of the famous pass of Roncesvalles (page 326). I found an inn that might have sheltered the Three Musketeers, and there I ate trout caught that morning in the Nive.

The next day took me through Mauléon,

* See "Life in the Land of the Basques," by John E. H. Nolan, National Geographic Magazine, February, 1954.

which still remembers Charlemagne and the Moors in an annual mystery play, and on to the Vallée d'Ossau. The road became more somber as it climbed into dark mountains. Fir trees stood in the moving mists, and nearly all the torrents were encased in pipes.

Hydroelectric power stations throbbed in the solitude, then all signs of man vanished. I went up into a land of rocks and boulders where the young rivers and waterfalls, too small yet for confinement, gurgled over pebbles. It was odd to think that these little streams, hardly a yard wide, were probably fated to drive the Sud Express and light the windows of Toulouse.

Spanish Sun Brightens France

It was a steep pull up a cold and barren road to Portalet Pass, at the frontier with Spain. French customs officers, their coat collars turned up, ran out of a hut and waved a car down into Spain.

The heavy clouds over France seemed to brighten. I said to one of the police that the sun would soon come out.

"*Non, m'sieu,*" he replied, "you are wrong. The light you see in the sky is from Spain, where the sun always shines."

On the way down I had a wonderful view of brooding, 9,465-foot Pic du Midi d'Ossau. The road looped down through fir trees and then began to climb the Col d'Aubisque where, from the highest point of the pass, I looked upon a chaos of great mountains.

Here I found a group of English hikers. They were interested to hear that I had been on the Spanish side of the range and asked me if I had thought it very different.

"The difference is," I told them, "that in Spain you are always traveling in the foothills with the main range like a mighty wall beyond you, but in France the roads penetrate the inmost recesses of the mountains."

Football Stronghold

Just as it was growing dark I came down into the bright little town of Argelès Gazost.

The lower floor of my hotel was a bar where local men gathered in a fog of tobacco smoke to play cards and dominoes.

I was rather puzzled by a blackboard with a chalked announcement of some contest between "U.S.A." and "U. S. Cazaubon." The proprietor told me that "U.S.A." stands for Union Sportive Argelès, and that the game was Rugby football. In this district of Béarn they despise pelota and believe that Rugby is the one and only game for men.

My host, an old Rugby player himself, told me that Lourdes, only eight miles away, had several times been the champions of France. This was an entirely new aspect of Lourdes to me, but to him the famous town of miracles meant mainly Rugby football.

Toward bedtime two tired young men came in and made a dramatic announcement that stilled the babel of talk and the noise of dice.

"Snow is falling on the Col du Tourmalet!" they said.

Snow, the first of the year! It is always news. So the year had turned the corner toward winter. The card players and the others looked at each other for a moment, reflecting how this change in climate might affect them. To me it was devastating, for I had planned to go the following day across the Col du Tourmalet to the observatory, which stands just below the summit of the Pic du Midi de Bigorre, at a height of more than 9,000 feet.

"You will never do it now," said the newcomers. "By tomorrow there will be a foot or two of snow on the passes."

Lourdes Draws 2,000,000 Pilgrims

In the morning I went to Lourdes. I had never been there before and was full of curiosity, for in all the Pyrenees there is no place more famous. It was a Sunday morning. Motor coaches were piling in, several each minute. I managed to find a room in a hotel full of German pilgrims.

The fame of Lourdes began in 1858 when a peasant girl, Bernadette Soubirous, had a vision of the Virgin Mary in a grotto near the river. The Church was at first unsympathetic and considered the girl to be hysterical, but the wonders performed there drew thousands to Lourdes, and in 1933 Bernadette was canonized. Today more than two million pilgrims visit Lourdes every year from all parts of the world (page 310).

All day long crowds milled around the cathedral, but the greatest interest of all was reserved for the famous grotto where Bernadette had received her visions. I joined a queue of many thousands, most of them grasping candles they would leave at the shrine. Slowly we approached the cave, which looks today much as it did a century ago.

A statue of the Virgin has been placed in the exact spot above the entrance which Ber-

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Medieval Gate Straddles a Lane in St. Jean Pied de Port, France

Founded about A.D. 700 at the approach to Roncesvalles Pass, the mountain town shared the vivid history of the Pyrenees' western gate to Spain. With the discovery in the 9th century of the tomb of St. James the Apostle in Galicia, countless pilgrims streamed past this way station. Here the Bridge of Spain crosses the Nive.

nadette pointed out as the place of the apparition. As we entered, we were watched by hundreds of cripples and invalids drawn up in rows in front of the grotto, sitting in wheel chairs or lying on stretchers.

The atmosphere was tense. The invalids prayed incessantly and told their beads. The hundreds of candles guttered in front of the shrine. I expected at any moment to hear someone shout that he or she had been cured, but this did not happen, and the whisper of prayer continued all day long.

Torches Make a Fiery Lake

The torchlight procession that night was one of the most spectacular things I have ever seen. There is a space in front of the cathedral nearly as large, I fancy, as the plaza of St. Peter's in Rome. As I approached it, I saw a multitude of singing people, perhaps 20 abreast, visible only by the light of a candle which each held in his hand. They advanced, so slowly that they hardly appeared to move, down the hill at the back of the cathedral toward the open space.

As they reached it, they were sent to their places by marshals, and slowly the enormous dark space began to fill with tens of thousands of winking, glittering pinpoints of fire. Still the pilgrims continued to advance down the hill for an hour and more, until finally the enormous square was a lake of flickering light.

When I reached my hotel that night, a little old Irishwoman was standing in the hall still holding a candle stub with the words of the "Hail Mary" upon its cardboard shade. She was lost. In the most charming brogue she asked me the way to her hotel in the upper part of the town. I got out the car and drove her back.

"All my life I've been saving up for this pilgrimage," she told me. She sighed happily. "And now it's in Lourdes I am, and I can't believe it. Glory be to God, think what I shall be able to tell them when I get home!"

Descent into Dank Caves

Ten miles from Lourdes are the famous caverns of Bétharram. M. Casteret's vivid NATIONAL GEOGRAPHIC articles on the wonders to be seen underground in the Pyrenees were in my mind as I went off to the caverns.*

The entrance lies on the one side of a ridge, the exit on the other. I descended with other visitors in a lift that deposited us in a chilly dark place, where an enthusiastic guide took charge of us. He switched on lights concealed behind stalagmites and stalactites, and we gasped as we saw the enormous and uncanny cathedral in which we stood: a cathedral with grotesque spires, with towers all askew, with crypts opening at our feet—a fantastic jumble of odd and unreasonable shapes and fantastic colors.

The architects of these under-landscapes are, of course, the subterranean waters of the Pyrenees. In the course of centuries they eat their way into the softer rocks; then, when the water is deflected, you have a cavern.

As we plunged deeper into the mountain, down a stairway cut in rock, we were grateful for the rope handrail. Underground rivers boomed in their channels. Drips of ice water fell on our faces. Suddenly the guide switched off the lights for a few seconds, and a woman screamed.

We continued to descend into this underworld where giant stalactites taller than a human being hang from the roof. They were formed by centuries of relentless drops, and each drop helped to increase the stalagmite beneath, which over the years was imperceptibly rising to meet its chilly parent.

Boat Plies an Underground Stream

In hundreds of places the two had met to form a column. One looked at them in awe, conscious of the great span of time represented by their meeting. I saw a young stalactite just beginning, a thing an inch long, cold and wet, and I wondered what would have happened in the world above by the time it had grown to be a foot in length.

The caverns are in four stories, the deepest a mile and a quarter long. As we approached it, we heard more rivers running in the darkness and saw one gliding through its gorge, then suddenly vanishing into the rock. Most uncanny of all, we heard the splash of oars and came to an underground stream, black as pitch in the torchlight, where boats were waiting to take us across.

No one spoke; even the humorist of the party was silenced. Then we stepped ashore and began to ascend. At once our spirits rose, for we were on the way out.

What a long climb it was back to the sunlight, and with what delight I went on through the pale autumn sunlight to see what might

*See, in the NATIONAL GEOGRAPHIC MAGAZINE: "Probing Ice Caves of the Pyrenees," March, 1953; and "Discovering the Oldest Statues in the World," August, 1924, both by Norbert Casteret.

Bathers at Biarritz Play on the "Coast of the Silver Spray"

Victor Hugo wrote in 1843: "I know no spot more charming and magnificent than Biarritz . . . . One leaves the village . . . and suddenly one finds oneself on a gentle, smooth, sandy shore in the midst of an inextricable labyrinth of rocks, chambers, arcades, grottoes, and caverns—a strange architecture, flung in confusion among the surge . . . I have but one fear . . . that it may become fashionable."

Hugo's fear was realized 10 years later. Empress Eugénie "discovered" Biarritz, and the rich and famous began to troop there. Sir Winston Churchill, the Duke of Windsor, and Elsa Maxwell frequent this French resort.

Here on the Grande Plage (Great Beach), a high, pounding surf endangers swimmers.

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← Basques Dance in San Sebastián

Leaping, the men touch legs together like birds beating their wings. These were eight of 2,000 Basque performers seen by the photographer in this Spanish bull ring.

↓ Medieval-style headdress and detachable sleeves adorn a fiesta-goer in Ansó, Spain. Medallion and gold pendants represent the Virgin of the Pillar, Aragon's patron saint.

© Kodachromes by B. V. Morton [illegible]

be considered the greatest natural wonder of the Pyrenees, the famous Cirque de Gavarnie. These cirques are a characteristic feature of the Pyrenees and occur chiefly on the French side of the range; the Cirque de Gavarnie stands back to back with the National Park of Ordesa in Spain.

I came to a road that twisted over the flanks of the mountain of Coumély into a valley wild and awful like a scene from *Pilgrim's Progress.* The sun disappeared, and gigantic clouds took possession of the sky. It was now bitterly cold, and I could feel snow in the air.

Storm Clouds Veil Gavarnie Cirque

I approached a windswept huddle of buildings at the end of the valley, the village of Gavarnie. It was characteristic of the French Pyrenees that a tourist coach was already there. Some of the sightseers sat warming themselves in a little cafe, drinking coffee and eating sandwiches; the others had mounted ponies and ridden on to see the cirque.

When I found myself in the Cirque de Gavarnie, I stood astonished by a scene that has no parallel in the Alps or in any other mountain land I know (page 303). The wall of mountains stands 5,000 feet above the floor of the cirque and forms the segment of a circle with a radius of about five miles. The mountains, terrible as doom, were black, matching the dark clouds that moved above them, and their flanks were streaked with nearly 20 waterfalls that noiselessly feathered their way to earth.

"I have seen the Cirque de Gavarnie many times but always in the sunlight," said a French tourist. "This is more stupendous."

"Would you agree with Victor Hugo, who called it the Colosseum of Nature?" I asked.

"Well, today," replied the Frenchman, "I should say it more closely resembles Valhalla!"

"And Wagner in his stormiest moments," I put in. "Is there a fitter background on earth for the Ride of the Valkyries?"

Later that day I crossed the Col du Tourmalet. Huge sheets of mist went whirling across the desolate moorland, and the edge of the road ended in a swirling whiteness in which now and again I could make out the top of a pine forest.

Then came the Col d'Aspin, and from its summit I looked down into the glorious Vallée d'Aure. Beyond lay other valleys enclosed by mountains that piled up into a tremendous skyscape stretching south to the Spanish border and the giants of the Maladeta (page 332). When I turned and looked the other way, I saw the Pic du Midi de Bigorre, its sides streaked with white (page 313).

I came to Arreau, which lies in the valley among patchwork fields, and before dark I arrived at Bagnères de Luchon, an elegant Pyrenean spa in France. This beautiful little town with its setting of mountains and its dignified balconied houses, many of the 18th century, recalls an age of candlelight and satin. Some memory of Versailles seems to linger in its pretty parks and formal avenues. It is a charming French version of Bath.

Listening to the news on the radio that night, I heard that snow was falling on the Col d'Aspin and that the road was closed. How fortunate I had been.

"M'sieu," said the owner of the hotel where I stayed, "we now face the most beautiful time of our year—winter. The first snow is falling, and soon all the mountains will be white.

"In a few more weeks the air will ring with the shouts of young men and women as they go up to the ski lift with their skis, and this old town, which in summer is filled with elderly invalids, will rejoice in the sight of hearty young people enjoying life. Ah, m'sieu, I love the winter. It brings youth and laughter to the mountains."

"You are a poet, m'sieu?" I asked.

"By no means," he replied. "Just an old man, but not too old, m'sieu, to think that one of the prettiest sights on earth is a fine young woman, her face red like an apple with the sharp air of winter, and snow melting in her hair."

Autumn Air Etches the Peaks

In the morning I was off and away through Montréjeau and Tarbes to Pau, that fine city where, lifted above the waters of the Gave de Pau, the Boulevard des Pyrénées faces the distant mountains.

They were clear that day, standing up in the bright, crisp air. From east to west I recognized them—the Pic du Midi de Bigorre, Gavarnie, the Pic de Vignemale; and so on to the fine skyline of the Pic du Midi d'Ossau. Behind them rose the distant mountains of Spain.

There they stood in the autumn sunshine—the Pyrenees.

Christian and "Moor" Ride in Peace Before Battle in Mauléon, France

Prior to the shepherds' departure for the mountains in spring, the Basques of Mauléon stage a *pastorale*, a 20th-century version of the medieval miracle play.

Actors start festivities with a parade through the streets (above). Arriving at an open-air stage, they fight, sing, and dance for hours.

Year after year the theme stands unchanging—a struggle between good and evil, God and Satan. Angels and devils, postmen and policemen, emperors and kings flood the stage, then desert it. A hangman does his duty. The Voice of God booms out, and Gregorian chants fill the air. Moslems charge with swords; Christians in cocked hats and blue coats (background) return the attack.

The plot appears but dimly through the waves of actors and costumes. But the story of Robert, one whose soul belongs to the Devil, has survived since the 15th century.

Here a dancer in the helmet of a French dragoon of the 1800's rides a white work horse. His companion in towering flower hat and red jacket represents the invading Moors from Morocco and Spain.

→A Churro ram gets parade directions from his shepherd.

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Pocket-size Vallée d'Aure Once Nurtured an Independent Swiss-type Republic

From 1300 to the French Revolution the Golden Valley enjoyed an autonomy like that of present-day Andorra (page 334). Today it is a part of France. These visitors sit atop the Col d'Aspin

Route des Pyrénées Zigzags Past Patchwork Farms and Fir-clad Slopes

Grainfields and vegetable plots lie near the town of Arreau (behind the hill at lower right). The Neste, which threads the glen, empties into the Garonne. Spain begins at the horizon (right).

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↑ House and Barn in Vallée de Campan Unite Under a Mantle of Thatch

Pyrenean marble beautifies French cathedrals and palaces. Fountain basins at Versailles employ the stone. Campan gives its name to a variety of green marble streaked with red and white. This French farmer and his wife harvest potatoes.

↓ Tobacco Shingles Home and Shed in Tiny Mountain-walled Andorra

In a world increasingly bound by restrictions, the Andorran farmer enjoys rare liberties. He pays few taxes; his government incurs no debt. He observes no written laws and supports no standing army, navy, or air force.

Men Who Measure the Earth

Surveyors from 18 New World Nations Invade Trackless Jungles and Climb Snow Peaks to Map Latin America

By Robert Leslie Conly

National Geographic Magazine Staff

With Illustrations by National Geographic Photographer John E. Fletcher

On a windy mountain 15,590 feet up in the Peruvian Andes, I huddled next to a campfire and waited for the sun to set. As the shadows stretched longer, the air turned bitter cold. The few drops of water in my canteen cup froze solid; my feet felt as if they were going to do the same thing.

To the east a bank of gray clouds mounted ominously, but to my relief they stayed high, so they would not interfere with the operation I was about to observe. Within an hour numb-fingered engineers on the mountain where I sat—and on four surrounding snowcaps—would begin a series of scientific observations to measure the earth.

Perhaps you thought, as I once did, that geographers already knew the earth's shape and dimensions. And so they do, in a general way. They know it is more or less round—a spheroid, or near-sphere—and flattened at the poles, with a middle-age bulge around the Equator. But precisely how flattened, how big a bulge, and how nearly spherical—even the experts don't know.

They are eager to find out. In this age of guided missiles, the *exact* distance from, say, Tallahassee to Timbuktu may suddenly become crucially important. And as of now there is no way to calculate this distance except to know the size and shape of the earth's surface between the two cities.

Night Lights on Snowy Peaks

Presently National Geographic photographer Jack Fletcher, barely recognizable in a bright wool *chullo*, an Indian mountain hat, joined me at the fire's edge. With cold-clumsy fingers he worked to insert film in his camera.

"I just made a bad mistake," he said.

"What was that?" I asked.

"I moved."

Even mild exercise is exhausting three miles up. After six hours of it, we were both feeling symptoms of *soroche*, mountain sickness, caused by too little oxygen in the air. My head and jaws ached alarmingly, and my neck was so stiff I could not look over my shoulder. The mere thought of eating was nauseating.

As we sat by the fire and swapped symptoms, a shout rang out behind us.

"Here come the lights!"

The sun had finally set, and the brown mountains turned purple and black. Suddenly, on top of a snow peak six miles west and 2,000 feet above us, a pinprick of light glowed like a fallen star. Behind me, to the east, another light blinked on; then a third and a fourth.

A Girdle for the Earth

This was what we had come to see. These specks of light, actually powerful battery-run signal lights shining incongruously from peak to peak in a mountain wasteland, were instruments to map a still largely uncharted continent and, in the process, to fit a new girdle to the planet earth (page 336).

The hard work in making maps is not done at a drawing board. It is done by geodetic surveyors—specially trained engineers who cross and recross the country through deserts, mountains, and jungles.

As they go, they establish thousands of control points at which latitudes, longitudes, and elevations are determined. The word "geodetic" means that measurements are adjusted to allow for the curved shape of the earth, which geographers call the geoid.

Fletcher and I were here to report and picture one of the biggest geodetic and mapping programs ever undertaken anywhere, the first attempt in history to map a continent as a whole rather than piecemeal. It is an all-American project, being carried forward jointly by the United States and 17 Latin American nations.* Coordinating the work is

* Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Peru, Venezuela, working according to specifications adopted by the Pan American Institute of Geography and History.

Shivering Surveyor in the High Andes . . .

Mapping the still largely uncharted continent of South America, U. S. and Latin American engineers and soldiers are swarming up 18,000-foot peaks, camping in jungles, and exploring the Amazon's headwaters.

Eighteen countries, including the United States, are working on the program, which is coordinated by the Inter-American Geodetic Survey (or IAGS), a mapping agency of the U. S. Army.

Before maps can be made, geodetic surveyors must crisscross each country, putting in basic controls identified by bronze disks painstakingly established as to latitude, longitude, and elevation, and firmly fixed in concrete or stone. All parts of

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← Colored Lights Guide Engineers

When a survey leads through a city, engineers set up their instruments on the highest building available. To distinguish their station lights from street lamps and neon signs, they may use prearranged groupings of colors. Red, white, and blue signals flash at sunset on this clock tower in Diriamba, Nicaragua.

. . . Peers at a Signal Light 6 Miles Away

the map are drawn in reference to these control points.

Surveyors accurately determine distances of hundreds of miles by triangulation, a process by which two of a triangle's sides are calculated from measured angles and a known base line (page 357). They form such triangles by setting up lights on mountain peaks. Normally they work at night, when warm air currents subside.

Here at dusk engineer Norman Fassett sights his theodolite on a light atop 17,085-foot Mount Sorpresani, near Tarata, Peru. He himself works at 15,390 feet. His signal light (20 feet away) provides a target for an observer on Sorpresani.

Indian-style Cap Warms Ears →

Mr. Fassett's $2,100 theodolite combines a high-power telescope and a microscope mounted on a swivel. When the telescope is sighted on a distant light, the microscope reads degrees, minutes, and seconds from two illuminated glass circles in the base.

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the Inter-American Geodetic Survey (IAGS), an agency of the U. S. Army Corps of Engineers. It is known throughout Latin America as *Servicio Geodésico Interamericano*.

At its headquarters in Fort Clayton, Panama Canal Zone, Col. Robert R. Robertson, the affable and energetic Army engineer who directs IAGS (opposite), told me how it first came into being.

"During World War II," he said, "we learned the hard way that adequate maps just didn't exist for most parts of the globe. Even in the United States, only 37 percent of the land is covered by really accurate topographic maps.

"When the war ended, the President started a long-range plan to promote map making, with United States technical help, in friendly countries all over the world. The Army, Navy, and State Department were directed to cooperate. The Army named its Latin American program MAPPLAN. The IAGS is MAPPLAN in operation."

Case of the Missing Mountains

"Many of the existing maps of Latin America," Colonel Robertson told me, "were compiled from whatever information was available—aeronautical charts, rough sketches by explorers and prospectors, missionaries' charts, and sometimes just guesswork.

"Right here in Panama there's a mountain range 125 miles long, with peaks up to 5,000 feet, that did not show at all on previous maps. Rivers are sometimes 40 miles out of place.

"Some results of our work, incidentally, have shown up already in the National Geographic Society's new map of Eastern South America. Your own cartographers can tell you how many mountains they had to raise and how many Brazilian rivers they had to relocate when they compiled it."

Navigation problems raised by supersonic flight, as well as by an increase in long-range night flying, gave new urgency to the other part of IAGS's assignment: finding data to determine the size and shape of the earth. These data will come from a continuous overland measurement running all the way from Alaska to southern Chile.

IAGS, Colonel Robertson stressed, is no giveaway program. The bulk of the actual work is done by the 17 collaborating countries themselves. In terms of dollars, for example, these countries annually spend over three times as much as the IAGS. In terms of personnel the ratio is even more impressive: about 660 United States workers as compared to more than 4,000 Latin Americans.

The United States engineers, pilots, cartographers, and other assorted technicians have made up a kind of slogan from the initials of their outfit. IAGS, they say, means "I'm Always Going Somewhere." And so they are. A man just back from hacking his way through stifling jungle, may, the following month, find himself encamped on a frozen mountaintop or paddling down the Amazon in a dugout canoe.

For two months last year I lived and worked with these men, slept in mosquito-infested jungle bases, sweated on horseback under a broiling tropical sun, paddled in leaking *cayucos*, and skimmed over hundreds of miles of thick green forest in small one-engine planes and helicopters. It is no soft life.

Yet this is high-precision work they are doing, with fragile scientific instruments costing thousands of dollars apiece. Just the names of the tools are enough to bewilder a layman: the theodolite, the pendulum astrolabe, the chronograph, gravimeter, geodimeter, and the magnetometer, to name a few.

The instruments are delicate, but not the men who use them. Consider Earl Meador, for example, who was struck by lightning in the line of duty. In Venezuela I met Earl, a quiet-spoken young engineer from Kentucky.

"I was working on a mountain about 13,000

Page 339

Map Makers Plan a Massive Task: → the Charting of a Continent

Inter-American Geodetic Survey was established in 1946 after World War II had revealed the scarcity of adequate maps for most parts of the world, including South and Central America.

Using the most modern scientific methods, the survey has set up a control system extending from Atlantic to Pacific and from Mexico to southern Chile, and containing thousands of points at which latitude, longitude, and elevation have been determined. Aerial photography, another stage in map making, is now under way.

Finished maps, on a scale of 1 to 250,000, will be produced by Army Map Service in Washington, D. C., and by map-making agencies in the 17 cooperating countries.

Here Maj. Gen. Lionel C. McGarr (left), who commands U. S. Army forces in the Caribbean area, confers with Col. Robert R. Robertson, Director of IAGS, at Fort Clayton, Panama Canal Zone, the headquarters of IAGS. National Geographic maps cover the work table. The IAGS emblem, woven in flowers, marks the survey's anniversary.

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SERVICIO GEODESICO
INTERAME
CANO
SOUTH AMERICA

Engineers in Managua, Nicaragua, Tread Gingerly on a Flower Bed

To IAGS surveyors, the new National Stadium is a picture point; that is, it is identifiable in an aerial photograph. Before cartographers can use the picture for mapping, several such points must be located as to latitude, longitude, and elevation.

These surveyors sight on a calibrated rod near the stadium entrance. Their instrument, called a Wild reduction tacheometer, can measure the distance to the rod as well as its relative elevation and horizontal position. Statue honors Nicaragua's President Anastasio Somoza.

feet up, near Huancayo, Peru," he told me. "We were setting up a theodolite about 4 p. m. It was cold, and I was wearing a fur-lined parka. That's what saved me, I guess.

"It began to snow and sleet, and I heard some thunder. Then a bolt of lightning flashed down and hit me on the back of the head. I couldn't see it because it knocked me out cold. But another man up there with me said that lightning ran right down the back of the parka and into the ground.

"It made me feel pretty bad. I couldn't even work that night."

Earl Meador was one of the lucky ones. He lived to tell about it. Others have been killed by lightning; still others have died in plane crashes, drowned, frozen, been menaced by jaguars, or struck by deadly tropical diseases.

This is not to say that IAGS has an unduly high mortality rate. It has not. Strict safety regulations govern all its operations, and they are observed. But the nature of the work is hard and hazardous.

Monuments on Mountaintops

The trademark of the geodetic engineer is a bronze disk about 3½ inches in diameter. If you have hiked or camped in the mountains or along the seacoast in the United States, you have probably seen them, set in solid rock or concrete. In the United States they are often stamped with the name of the U. S. Coast and Geodetic Survey, and the warning: "$250 fine or imprisonment for disturbing this mark. . . ." In Latin America the IAGS disks are similar, but the legend is in Spanish.

There are tens of thousands of these monuments in Latin America. In cities, you may find one in the cornerstone of the governor's palace, or in the base of Bolivar's statue in the park. They lie buried under snow in the Chilean Andes and hidden (but never lost) in thickets of the Amazon jungle.

There's a story about a party of mountain climbers who arrived in a Central American city and announced with some fanfare that they were going to scale for the first time a near-by 11,000-foot peak, regarded as difficult and risky. After a send-off by the mayor, the mountaineers set out. They made it to the top, too, but there the fanfare fizzled out. Embedded in rock on the summit they found a "*Servicio Geodésico*" disk. It seems an IAGS engineer had climbed the peak two years earlier, planted a monument, made his observations, and climbed down again without bothering to tell the local papers.

A dot marks the center of each disk. The job of the geodetic surveyor is to plant the disks immovably, and then to determine the precise location of the dot—its latitude and longitude, or elevation above sea level, or both. Like the numbered dots on a child's drawing puzzle, these disks, placed along mountain ranges, valleys, rivers, and roads, form the framework around which a map will eventually be drawn.

The geodetic surveyor must go where his compass leads, regardless of hardship or danger. Sometimes he must turn explorer, push-

ing his way through unknown terrain. For jobs like this, the IAGS employs specialists.

In Nicaragua I met one of the specialists. Frank Herbst is a bushman, and looks the part (page 346). He stands well over six feet; his face is weather-beaten from years of living without benefit of wall or roof. He is an expert with pistol, rifle, and shotgun.

Trek Across a Continent

Once, when he found himself at loose ends in Cochabamba, Bolivia, Herbst decided he would rather be in Georgetown, British Guiana. He set out on foot, switching to cayuco when he could—a trip of over 1,700 miles across part of the high Andes and through the Amazon jungle of Brazil.

"It took me about four months," he admitted, "but I was in no hurry."

When there is particularly rough country to be surveyed, Herbst goes through first, armed with revolver, machete, and high-powered rifle, to find the best route for the geodetic engineers as they establish control points.

I met Herbst in Puerto Cabezas, a small lumbering town on the Mosquito Coast of the Caribbean (map, page 344). His task was to reconnoiter the wild coastal area from Puerto Cabezas north to the Honduran border.

When I arrived, Herbst had already flown along the coast in a small two-seater L-19, one of 45 U. S. Army aircraft authorized to IAGS (page 342). One of his objects was to pick out stations—high points of land visible from one to the next—on which the engineers later would set up their instruments.

"Now I have to reconnoiter each station on foot," Herbst said. "I go to the first one tomorrow. Why don't you come along?"

We left the next morning at 6:30, Maurice Tewinkel, an IAGS engineer, Herbst, and I. In a rented truck we lurched and bounced the first 10 miles across a dirt track to Crukira, a Mosquito Indian village north of Puerto Cabezas. There, to cross a wide lagoon, we rented a *pipante*, a dugout canoe. We paid five cordobas (about 70¢) for it. It turned out to be less of a bargain than we thought. A huge leak in the bow almost swamped us before we reached the other side.

Plane Drops Glittering Foil to Mark a Survey Station

Light planes of the U. S. Army enable IAGS surveyors to spot the easiest routes through rough terrain and pick the best sites for stations.

Helicopters, transporting men and gear, save days of hacking through jungle. Airlifts of food obviate tedious pack trips.

This L-19, having dropped a streamer of foil to mark a station in Panama, speeds on to find another site.

← Page 342: When the plane has finished reconnaissance, a helicopter flies in an engineer to begin ground operations. This man is being lowered by a sling to save the 'copter's rotors from damage in brush.

→ After landing amid the identifying foil, the engineer pinpoints his position on an aerial photograph so that other surveyors can find it.

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Latin America Survey Paves the Way for Progress

Oil, minerals, lumber, water power, and fertile virgin soil lie untapped in the 17 countries collaborating with IAGS. Their development cries for detailed maps to guide the men who someday will build the roads, railroads, pipelines, dams, and airfields.

The maps are coming. In Venezuela's oil-soaked flatlands, along Nicaragua's lonely Mosquito Coast, and around Lake Titicaca's lofty shores the author watched United States and Latin American engineers working side by side to produce the basic data. These men must establish some 91,000 miles of first-order triangulation and 195,000 miles of level lines. Flying crews must take hundreds of thousands of high-altitude photographs.

By the end of 1955 the job was about one-fourth done.

Not far away we found two Indians with four horses—small animals, but sturdy enough. Here Frank struck another bargain. Why walk when we could ride? The two Indians announced they would come along, too. That made five of us, with only four horses. When we mounted our steeds, one Indian remained afoot, twirling a length of heavy rope.

I soon learned why. No amount of tongue-clucking or goading on my part had any effect on my animal. The Indian's job was to trudge behind us swinging his rope. When he caught up with a horse, the rope hit its rump with a "thwack!"—and the horse would trot briskly 18 or 20 steps. Then it would decelerate until the Indian got within thumping distance again.

At this jerky pace we rode for about four hours, first through jungle, and then, more comfortably, on the smooth beach of the bright blue Caribbean. At last we turned inland again onto a sandy plain, and there Frank stopped.

"Look," he said, pointing at a low hill about a mile ahead.

On the hilltop I could see something glistening in the tropical sunlight (page 343).

"That's our station," said Frank. "That shiny stuff is aluminum foil. I dropped it from the plane yesterday. It makes the station easier to locate."

On the hilltop Frank's main job was "verifying intervisibility"—making sure that this was the highest of several near-by hills, with a clear line of sight to the next station. Then, with a compass and a rough sketch map, he read and jotted down azimuths—compass directions—from our hilltop to the two other stations farther up the coast.

Finally he wrote down notes which would later be expanded into a station description, a report on the location and appearance of the hill and how to reach it, for use by the engineers who would follow.

The men who follow Herbst with lights and theodolites, bags of cement, and bronze disks will determine the distance from hill to hill, fixing the latitude and longitude of each sta-

tion. They will compute distances, just as surveyors have done all the way from Alaska to Chile, by triangulation.

"Triangulation," an engineer told me, "is half trigonometry and half endurance." Its principle is this: If you know the length of one side of any triangle and can measure the size of its angles, you may then, by an easy equation, determine the length of the other two sides.*

To start with, then, a line must be measured by hand, with a tape—the known side of the first triangle. After that, triangulation can go forward on its own, with each new triangle sharing a known side from the last.

Indians Collect Shiny Disks

Measuring a starting line, called a base line, must be done with extreme precision, since any error at this stage will affect all the other triangles (page 356). At each end of the line one of the familiar disks is set in concrete. And since primitive Indians sometimes like to collect shiny bronze disks, another concrete marker is usually buried three feet below the top one—a reserve marker in case the surface one disappears.

The base line finished, triangulation is ready to begin. The engineers themselves form the corners of the triangle, one side of which, of course, is the base line itself. Their measuring instrument is the theodolite, which combines a telescope and an angle-measuring device marked with degrees, minutes, and seconds (page 337).

Each man sights his theodolite on the other two—or, more accurately, on their lights—since precise triangulation is nearly always done at night. Each carefully measures the angle between the two lights he sees; to be sure he's right he measures it not once but 32 times. Then all three engineers, communicating by two-way radio or by blinking their lights in code, "close" the triangle—that is, add their figures to be sure they're right.

After that, of course, they are able to determine the length of all three sides. Using any one of these as the known side, they form a new triangle and repeat the whole process. Each new triangulation carries the measurement forward from 10 miles, in flat terrain, to 50 miles or more in mountainous country.

To watch a triangulation party at work, Jack Fletcher and I flew to Tacna in southern Peru, and drove northeast from there to the little Indian village of Tarata.

Here, working from a base camp 11,000 feet up, a crew of Peruvian cartographers and engineers were just attacking one of the toughest triangulation jobs, or "arcs," ever run anywhere. Working with them were three IAGS men, Norman Fassett, Tom McShane, and César Díaz.

"This arc will run from Tacna right over the Andes to Lake Titicaca," project engineer Fassett explained to me. "The average elevation of the stations we'll occupy will be more than 15,000 feet, higher than any point in the United States.

"Tomorrow the first party will take off for a station on top of Mount Pisacane, 17,524 feet high. It will take at least a day just to get up there; then they've got to tunnel through 11 feet of snow to get down to rock so they'll have a firm base for the station. The men will have tents, of course, to help break the wind, and small gasoline stoves."

Why did they choose such rugged peaks? Peruvian Army Lt. Fritz Du Bois's explanation was succinct:

"We can't see through them," he said, "so we've got to get up where we can see over them."

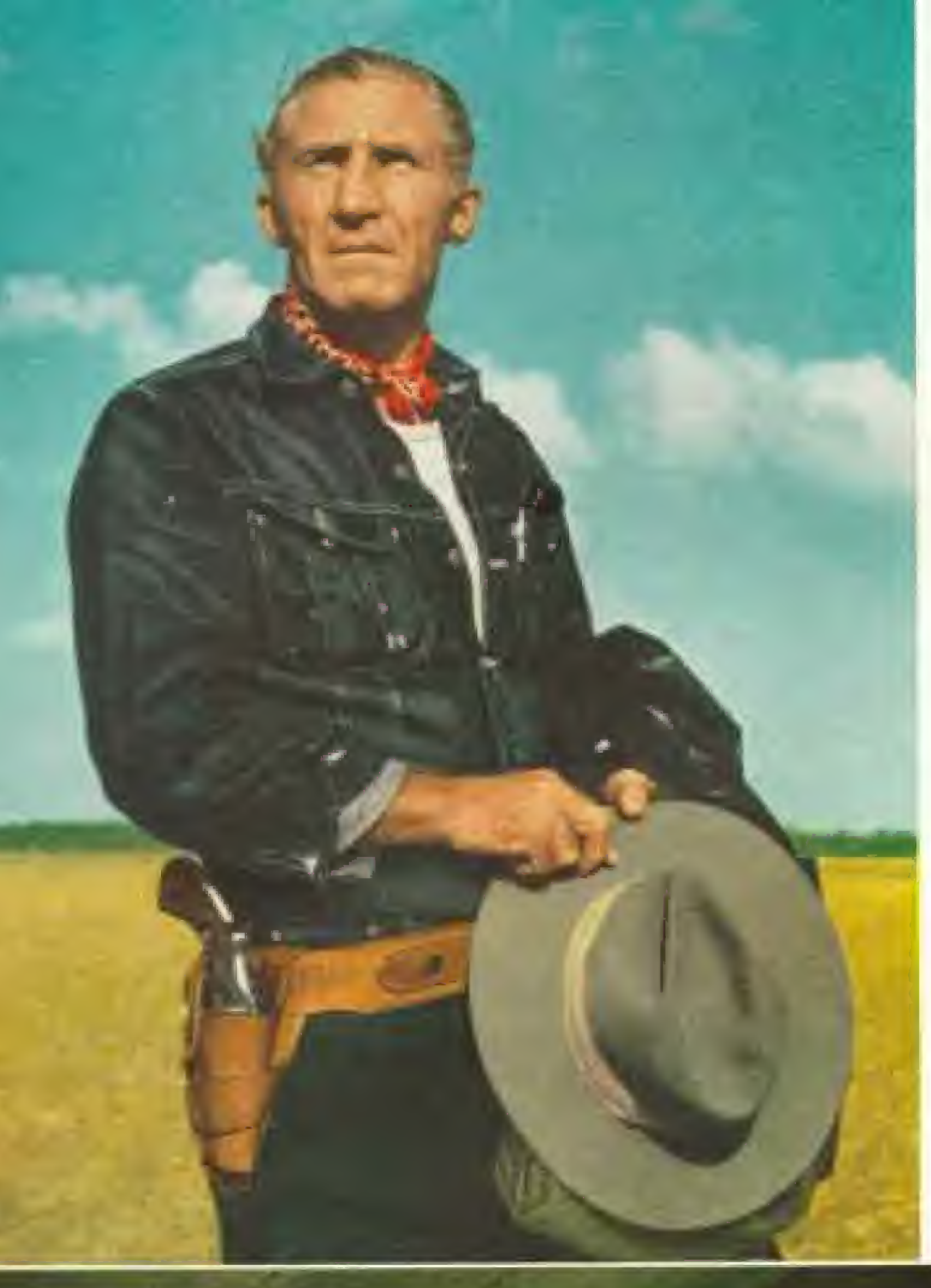
"We'll have one relatively easy station in this operation," Fassett added. "It's a supplemental station to bring the geodetic control down near the road that runs from Tacna to Puno. You could watch the whole operation from there, if you'd like. It's only 15,590 feet—not bad at all."

Eighty Days on a Mountaintop

The next day Fassett, McShane, Fletcher, and I set out for the intersection station—a round-topped hill on a lofty plateau ringed by loftier snow peaks. On our way we passed a herd of a dozen vicuñas, red-brown and slender legged, grazing in the coarse clump grass. As we approached, they fled single file up the mountainside.

As promised, the station was easy to get to. The hard part was staying there. This was where Jack and I got our taste of soroche. I, too, made the mistake of moving too strenuously. Rashly, I volunteered to help Fassett nail together an instrument stand, precut of two-by-four lumber, for his theodolite. Ten minutes of driving nails at 15,590 feet leaves your head aching and your ears ringing.

* See "Charting a World at War," by William H. Nicholas, NATIONAL GEOGRAPHIC MAGAZINE, November, 1944.



Jungle Trouble Shooter Carries Pistol on Hip

IAGS engineers in Latin America must extend surveys through country known to few except Indians. They face malarial mosquitoes, snakes, jaguars, and head-hunters.

When the going looks toughest, the IAGS is likely to tap Frank Herbst, onetime gold and diamond prospector, to blaze a trail. A former professional soldier in Europe and Africa, he has taught survival techniques to U. S. Marines. Born in Czechoslovakia, he speaks six languages fluently.

Mr. Herbst disappears into the bush with only a few pounds of provisions, relying on rifle or shotgun to bag game. He reappears with a rough map for the geodetic engineers who follow him.

↓ U. S. Airman Tries to Explain Shoran to Puerto Rican Girls

Measuring distances too wide for theodolites, the U. S. Air Force uses shoran, a radar device.

To tie the Antilles into maps of North and South America, radar beams are bounced from a high-flying plane to two ground stations and back to the plane again. From the elapsed time, measured in microseconds, mathematicians compute distances between ground stations.

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Kodachrome by David S. Boyer, National Geographic Staff Photographer

"Ideally," Fassett said, "the men on station up there should be able to finish their work and get off station in three days. Trouble is, there are so many things to go wrong."

"For instance?" I asked.

"Weather is the worst problem. In an IAGS project I worked on in Mexico, we had to sit on some stations six weeks before it got clear enough to see from one to the other. I know men who have spent 80 days on a mountain waiting for rain and fog to lift."

When this happens, new problems arise. Men on remote stations may run out of food or water after a few weeks. Frequently, triangulation parties take along shotguns or rifles to keep the camp in fresh meat.

Night Visitors—Human and Otherwise

Engineers have survived on berries, leaves, and roots while waiting for a plane to drop food. Water is even more of a problem. Unless there are parachutes, it bursts from ordinary containers when dropped from an aircraft. One headquarters chief had a bright idea: He scrounged some blocks of ice from a near-by city and dropped them to a field party, who simply gathered the ice and melted it down for drinking.

Weather and supplies are not the only hazards. In Costa Rica, a triangulation party chief, sleeping in a tent with four companions, woke up in the dead of night to hear someone—or something—scratching and snuffling near his bed. Suspecting that it was not one of his tentmates, he pulled a .38 revolver from under his pillow and said softly:

"Who's there?"

He received only a snarl for an answer, so he aimed the gun at a dark patch on the floor and started shooting. When the tumult died and somebody lit a lantern, they found their night visitor stretched dead on the floor—a jaguar six feet long.

Other nocturnal visitors have included Indians, who occasionally set fire to surveyors' tents. The Indians sometimes resist survey teams simply because they don't understand what the strangers are doing with their shiny instruments and flashing night lights. So awed were men of one primitive tribe in Colombia by the first appearance of an IAGS helicopter, which they mistook for a huge grasshopper, that they revised their calendar from that date. For them, 1955 was the "sixth year of the grasshopper" (page 348).

The old-timers, engineers who have been in the business for two or three decades, will tell you, with a faint undertone of nostalgia, that surveying has "gone soft."

"In the old days," said engineer Maurice Tewinkel, who isn't as old as this makes him sound, "if you had to go into the bush you went on foot, or at best on horseback. If you got lost or ran out of food, you were on your own. Now, with radios and jeeps and helicopters and airdrops, it's getting easier every year."

To support its operations, IAGS is authorized 25 light airplanes and 20 helicopters. It also has some 300 assorted trucks and jeeps, and 40-odd boats.

Most modern innovation, however, is Able Charlie Item, a 17-station shortwave-radio network which keeps IAGS projects in all collaborating countries in constant touch with headquarters and each other. (Able, Charlie, and Item are code words for the network's call letters, ACI.) Besides the 17 main transmitters, powerful enough for intercontinental talk, field parties carry shorter range portable two-way radios and walkie-talkies.

Yet despite all the modern machines, the air and ground support, and a growing network of roads, there are areas in South America where conventional triangulation is impracticable because it would be too slow and too costly.

Where the Amazon Rises

The most extensive such area is the vast region of swamp and jungle where the Amazon River rises, including parts of Brazil, Bolivia, Peru, Colombia, Ecuador, and Venezuela. In this almost impenetrable land tribes of Indians roam untouched by civilization, hunting game and each other with blowguns, spears, and arrows.

"The truth is," one cartographer remarked to me, "there's not much in there to map."

But I found men who disagreed. In the depths of this jungle, sailing down the swirling Marañón River in a small boat one day, I came on what I thought at first must be a mirage. On a bend in the river stood a white mansion, mounted on barges made fast to shore. Inside was a living room fitted with chrome-and-plastic furniture, comfortable bedrooms, hot and cold showers, fans and water coolers, and even a laundry room with automatic washers and dryers.

This was the mobile base camp of Texas Petroleum Company prospecting a 2½-million-

Venezuelan Children → Mob a "Grasshopper"

Within a 180-mile-wide circle near Ciudad Bolivar, the Venezuelan Government and IAGS are spending $1,000,000 on a project to find out, as one observer put it, "which way is down." Scientists are studying the force of gravity at thousands of sites around the center of the circle—the "datum point." Object: to eliminate the error in geodetic surveying caused by anomalies—the fact that irregularities in the earth's crust deflect gravity.

This fixed point may help establish positions all over South America.

Accustomed to airplanes, Indian villagers still get a thrill out of helicopters, which they sometimes call grasshoppers. This landing disrupted life in Magagua (population about 90).

← Peruvian Pupils Recite a Spanish Lesson

Following a survey team through the little-known headwaters of the Amazon River, the author came upon a rustic school in the Indian village of Barranca. Walled in by dense tropical forest, Barranca is a handful of thatched houses on the banks of the Marañon River.

Peru has compulsory free education for children from 7 to 16, but only in recent years has its school system reached into remote Indian settlements. Tribes still deeper in the jungle have no written language at all.

Plaque beneath the bell in corner reveals that this is public school No. 1529.

Four South American heroes look down on the class: Simón Bolívar (left), who freed much of South America, including Peru, from Spanish rule; Adm. Miguel Grau, who led Peru's Navy in the war against Chile; Gen. José de San Martín, Argentine soldier who fought Spanish rule; and Col. Francisco Bolognesi, who died in the Battle of Arica against Chile.

Señora Fernanda V. de Morales holds the pointer to the blackboard. Toddler in foreground visited the classroom to see what school was like.

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acre concession granted to it by the Peruvian Government. Herbert Edwards, the engineer in charge, showed me the maps they were using. The concession was outlined in bold straight lines, but the rest of the topography was so vague that, as one of the oilmen said, "You're never quite sure where you are."

To men like these, and others eager to develop the resources of this rich, untapped land, maps are all-important and urgently needed. Roads, railroads, oil pipelines, even adequate air transport, all require maps.

Rivers Are Only Landmarks

The data for mapping the headwaters of the Amazon are now coming, slowly and toilsomely, out of the jungle. The men producing the facts have jobs even lonelier than the triangulation men on their mountaintops.

An IAGS man named David Phillips, we were told, was camping in the jungle on the Pastaza River, which flows into the Marañon from Ecuador (map, page 344). His surveying operation was of a type we had not yet seen. "Astro work," the engineers call it.

Choosing sites some 15 miles apart along the major rivers, which are about the only landmarks in this flat, green sea of trees, Phillips was putting in monuments and determining their position by astronomy. The instrument he used was a pendulum astrolabe, a V-shaped telescope which looks into the sky at a fixed 60° angle.

No commercial airline would fly us into this remote country. In Lima, Peru, we appealed to Maj. Gen. Guillermo Suero, of the Peruvian Air Force, for help or advice. A reader of the NATIONAL GEOGRAPHIC MAGAZINE, he listened sympathetically.

"Try *Linguistica*," he advised us. "They'll fly you in."

Fine. But who or what was Linguistica?

Linguistica, I learned, is a popular name for the Summer Institute of Linguistics, an earnest group of young men and women from the United States who are studying Amazonia's primitive Indian languages and teaching the tribes to read and write. A majority of the teachers are women. To teach a tribe to read, they must move into the jungle with the Indians and live with them for as long as seven years.

At its jungle headquarters near Pucallpa, Peru, the Institute maintains several pontoon-equipped planes. When a teaching party, normally two women but sometimes a married couple, are ready to go to work, one of the planes flies them as close as possible to the place where their tribe lives. After they leave the plane, the teachers are on their own. Equipment includes a small food supply, machetes, and a portable two-way radio.

It is tedious work, learning the language word by word, compiling a simple dictionary, and then showing the Indians that "pictures can talk." At present 25 tribal languages are being studied in Peru.

A commercial airline flew us over the Andes to Pucallpa, trading post on the edge of Amazonia. From there a battered and brakeless taxi drove us over a mud road to Yarina Cocha (Palm Lake), the Linguistica headquarters.

This turned out to be a charming lakeside village with rambler-style houses, picture windows, and gardens bright with flowers.

"We cleared all this land by hand," Dr. W. Cameron Townsend, the Institute's director, told me. "With axes and machetes, it has taken us years, though of course a bulldozer could have done the job in a few weeks."

"But who supports all this?" I asked.

"The Peruvian Government gave us land," he explained. "Money comes from individual contributors in the United States and from churches. We're not really a religious organization, but we do introduce the Indians to Christianity by translating parts of the Bible into their languages. Our young people get their training in linguistics at the Universities of Oklahoma and North Dakota."

Mapping by the Stars

The next morning we flew from Yarina Cocha in one of Linguistica's planes, a one-engine Norseman. As we climbed, I could see the Ucayali River winding off to the north. The river would guide us and serve as a landing field in any emergency. Linguistica pilots try to avoid long flights over riverless stretches of jungle.

We had to make one such hop, however, from the Ucayali to the Huallaga River, which flows into the Marañon. It was on this wooded stretch of about 75 miles that our solitary engine coughed and suddenly died. For a few tense seconds we floated in silence broken only by the rush of air past the wings.

Then the engine roared again and the pilot apologized: "Belly tank ran dry. Sorry."

(Continued on page 359)

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↑ **Peruvian Survey Squad Starts Up a 17,200-foot Snow Peak in the Andes**

While surveying from peak to peak, United States and Peruvian engineers and soldiers camp at sites up to 18,000 feet without benefit of oxygen. Tents, gasoline stoves, and layers of clothing protect them against wind and cold. Here Peruvian Army Lt. Fritz Du Bois, who studied geodesy with the United States Coast and Geodetic Survey, leads the way up Nevado Ticaco, northeast of Tacna.

↓ Indian women in always-fashionable felt derbies offer potatoes and tuberous ocas for sale in Puno, on Lake Titicaca (page 353). "Irish" potatoes originated in the Andes.

Inquisitive Llamas Watch Surveyors Run a Level Line past Lake Titicaca

To find elevations above sea level, IAGS sends in crews armed with 10½-foot rulers called precise leveling rods. Hiking from sea coast to the heights, the men measure the land rise as they go.

Measurements are made by standing two leveling rods upright about 100 yards apart and placing a rotating telescope between them. When the telescope is precisely leveled, the observer reads the figures, first on one rod, then on the other. Subtracting the smaller figure from the larger, he determines the difference in elevation.

Rear rod and telescope then leapfrog forward, repeating the process. A bronze disk set in concrete marks elevations about once every mile.

This level party works near Puno, Peru. An umbrella shields the telescope from direct sunlight lest heat affect the delicate leveling mechanism.

Titicaca, at 12,506 feet, is the highest body of water of its size in the world.

Page 352, lower: Farmers' wives line up near Ticaco, in southern Peru, to apply for irrigation water. Spoonlike silver pins secure their shawls.

↓ "You Look Through Here..."

When the leveling group was working in Puno's Pino Park, crowds gathered to ask what was going on. Sgt. Bonifacio Rodriguez, of Peru's Instituto Geográfico Militar, endeavored to explain the operation of a Wild N-III precision level. His audience seemed more impressed by the sergeant than by the telescope.

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A Crew in the High Andes Works in a Landscape as Bleak as the Moon's

Engineers call their bronze, concrete-set disks "monuments." Three disks locate this control point: the triangulation station itself (right) and two reference markers 50 feet or so away. Arrows stamped on the reference markers point to the main station to help future surveyors find it in case drifting sands hide it.

A Hole Drilled in Stone Is Prepared for the Surveyors' Bronze Marker

Crews carry cement, water, sand, and stonemason's tools as they work through the mountains a few days ahead of the triangulation party. César Díaz, a Peruvian engineer, holds the disk. Once its position has been pinpointed, it will serve as a reference to map makers, road builders, and prospectors for decades to come.

-2

↓ Tower Lifts Men and Rotating Light over Trees

For surveying in level woodlands, helicopters fly in parts for light steel towers. A separate inner tower extending up through the surveyor's platform holds the theodolite steady.

↑ Yards of Red Cloth Protect Measuring Tape from Winds

Starting point and final check for all triangulation is the base line. If it is wrong, months of work may have to be repeated. Engineers therefore measure base lines, usually several miles long, with excruciating care. A 50-meter tape, checked by the U. S. Bureau of Standards, is pulled to a constant tension by a stretching device at one end (lower left). Windbreak helps maintain accuracy.

These engineers begin a 7-mile measurement near Ciudad Bolívar, Venezuela. Their line will be measured twice, once from each end. The two measurements must agree within one part in 300,000.

Page 356, left: When the spring balance shows 15 kilograms (about 33 pounds) of tension, a crew member marks the starting point of a section on a strip of metal tacked to a post, one of a set of markers placed at intervals along the line.

← A technician sets up a Worden gravity meter near the Venezuelan datum point (page 348). An $8,000 instrument, it can detect variations in gravity equivalent to the adding of 1/10,000,000 gram to a one-gram weight. The machine is so delicate that if knocked over it must be sent to the manufacturer in Texas for repair. Coming back, it must be carried by hand.

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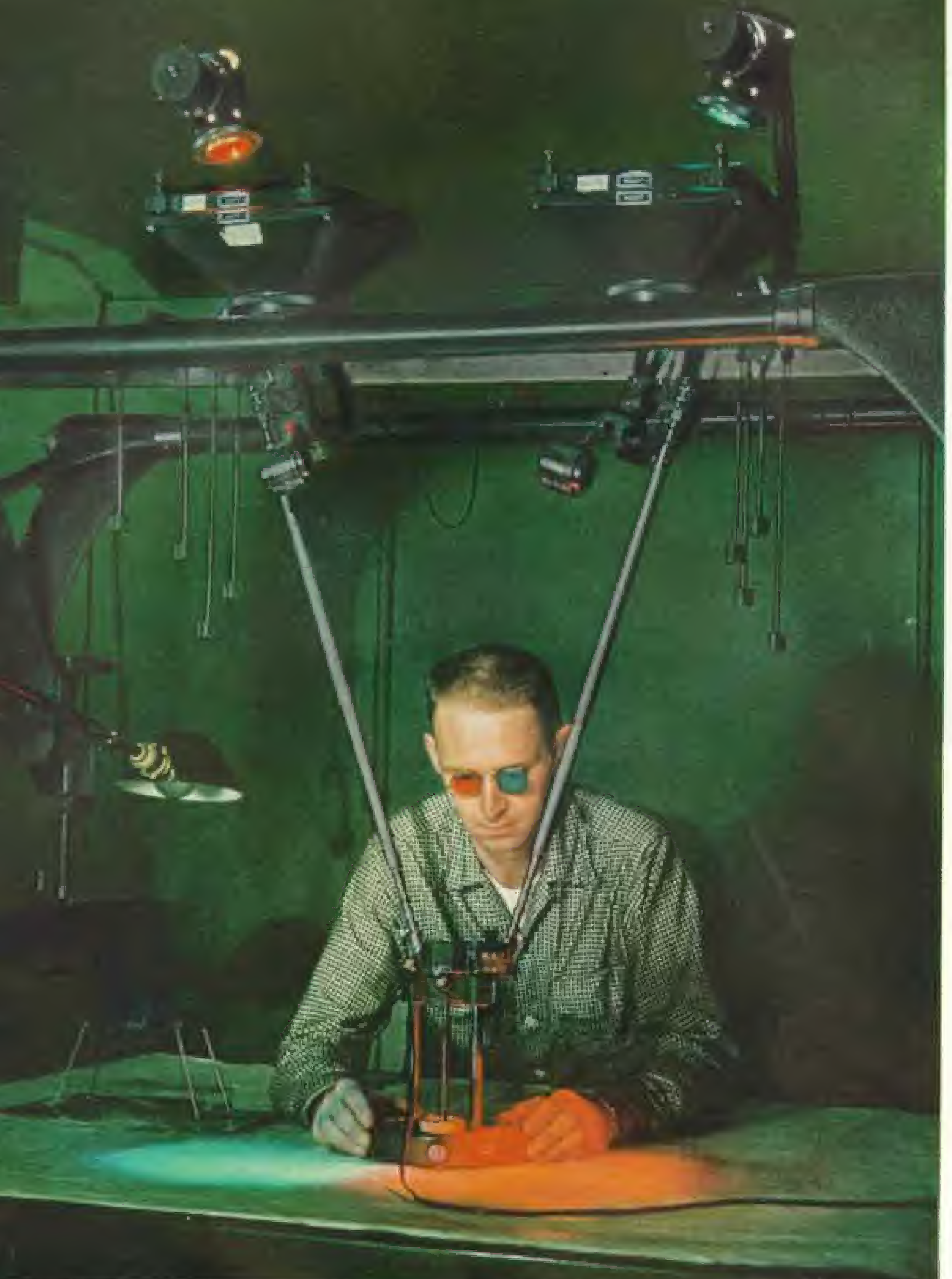

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Kodachrome by Staff Photographer Willard R. Culver

Using Red and Blue Lights, a Kelsh Plotter Projects Aerial Photos in Three Dimensions

Cartographers, in a final stage of map making, trace topography from photographs to map sheets. Here two projectors throw images from overlapping pictures onto the drawing table. Colored lights and matching lenses in spectacles create the illusion of depth, enabling the operator to plot contours.

We found Phillips at a bend in the Pastaza, camping in a wood-and-grass hut with six representatives of Peru's *Instituto Geográfico Militar*. After we had introduced ourselves, I gave him some mail I had picked up for him at headquarters in Lima.

"Thanks," he said. "This is the first mail I've had in a month. But come and eat some lunch. We were just ready to start."

He led the way to the hut. As we entered, I saw a table against one wall piled with figure-covered papers.

"Computations for our latest set of observations," Phillips explained. "It takes four or five days of paper work to determine each position after we're through observing."

As we ate lunch—rice and chicken with gravy—Phillips gave me a quick outline of the project and how he operates.

Work begins after sunset on clear nights. A shortwave radio picks up a time signal from the U. S. Bureau of Standards in Washington, D. C., 3,500 miles away. Its steady ticking of seconds is a weird sound in the jungle night. Phillips, having consulted a bulky astronomical manual, aims the blunt nose of his 80-power astrolabe at the path of a known star. He waits, as the clock ticks, until the star appears in his lens. Then he records the exact second it crosses the center of the lens, marked by cross hairs.

On a single night Phillips may "shoot" as many as 96 stars. From these data—the known path of each star, the time it crossed his lens, the direction his astrolabe was pointing—he can compute his position.

Hundreds of such positions at river bends and junctions and settlements will form the network of control on which a map of Amazonia will someday be based.

Tide Gauges Measure Sea Level

If you should walk around the coast of South America, you would find, every few hundred miles along the beach, a shack with an odd-looking machine clicking away inside. If you waited a day or two, you would notice a man enter, jot down some figures, wind the springs that run the instrument, and leave.

This is a tide gauge, a device which records on tape the daily rise and fall of the sea. Data from 80 such tide gauges are collected at IAGS headquarters to determine the mean sea level along both coasts.

Before a country can be mapped, hundreds or thousands of points in it must be measured for height above sea level, or, as the engineers say, vertical control must be established. This is not only because the map itself is expected to list elevations of mountains, cities, and passes. Aerial photography, on which modern cartographers depend heavily, can't be used for mapping unless there are at least three points in each photograph whose elevations are known.

This is because an airplane, flying over bumpy air currents, wobbles and tilts the camera. Aerial pictures are always distorted. Cartographers need three known elevations to compensate for the tilt in copying from photograph to map (opposite).

Working inland from the tide gauges, "level parties" move on foot, measuring land elevations as they go (page 353). They do it by the rather simple method of standing two rulerlike rods on end 100 yards or so apart, and observing how much higher the front rod is than the rear one. Having done this, and recorded the difference, they move the rear rod around to the front and do it again—and again and again—covering several miles a day.

Snapshots at 36,000 Feet

In the old days—up until a few decades ago—after horizontal and vertical controls were established, map makers took to field and hillside and sketched in landscape, relating key features to the control points. Nowadays the airplane speeds things up.

In Arequipa, Peru, a white and sunlit city with a bracing mountain climate, I met an aerial photographic team of six: two men, three cameras, and a P-38. They were working for Hycon Aerial Surveys, a United States firm with headquarters in Pasadena, California. Under contract with the U. S. Army Map Service, Hycon is collaborating with IAGS to photograph parts of Peru, Chile, Colombia, Bolivia, and Ecuador.

The human members of the team were pilot Sam Smith, from Minneapolis, reserve major in the U. S. Marine Corps, and Gilbert Mendoza, of Los Angeles, the photographer-navigator. Their P-38, a type used as a fighter and reconnaissance plane during World War II, is rated at 400 miles per hour (page 360). In its belly are set three aerial cameras, one pointing straight down, the other two oblique left and right. Their job is to fly back and forth across the area to be mapped, following parallel lines about five miles apart, snapping pictures every 15 or 20 seconds.

"What's your biggest problem on the job?" I asked the team.

"Clouds," said Smith.

"Cold," said Mendoza.

It all depends on where you sit. At 36,000 feet, outside temperatures fall to 50 or 60 degrees below zero Fahrenheit. The plane's heaters can't keep up with prolonged temperatures that low. Smith, in the pilot's plastic bubble, basks in sunlight and stays warm; Mendoza lies below and shivers.

As for clouds: "If there's even a little puff below you," Smith said, "and it shows in the photograph, they'll reject it. When it's really cloudy we can't work at all.

"And, of course," he added as an afterthought, "when we don't work we don't get paid."

How to Tell a Ball Park from an Airport

After the pictures are developed they are shipped back to the field for "picture-point control." The 3½-inch disks which mark basic controls are, of course, invisible in a photograph taken at 36,000 feet. So other survey teams must now extend this control, by more triangulation and leveling, to locate objects that show in the pictures: houses, road junctions, fence corners, even large trees. These are picture points (page 340). When the surveyors have fixed the latitude, longi-

Aerial Photographers Plot a Day's Work for Their P-38

Based in Arequipa, Peru, pilot Sam Smith (opposite page, left) and photo-navigator Gilbert Mendoza were assigned to photograph southern Peru and parts of Bolivia and Chile from 36,000 feet.

In flight, Smith follows parallel east-west lines drawn on a map at intervals of some five miles. Mendoza sets his cameras so that the area shown in each photograph overlaps that in the last one by 56 percent.

Film magazine on table holds enough to cover about 600 linear miles—roughly three hours' work from take-off to landing.

← Using a pocket stereoscope, IAGS surveyor Scott MacCalden places two overlapping aerial photographs together to get a three-dimensional view of an area he is mapping.

tude, and elevation of a picture point, they prick a pinhole in the photograph and write the data on the back.

Survey teams also identify topography which may not be clear in the photograph. A line across a field, for example, might be a road or a canal; a clearing may be a ball park or an airport. All must be shown with proper symbols on the final map.

IAGS, as its name makes clear, is not a map-producing agency but a geodetic survey. It transmits its volumes of data, horizontal, vertical, and astronomical, along with thousands of photographs, to the Army Map Service in Washington, D. C. Here the raw material will be turned into finished maps. The same data, of course, also go to the mapping agencies in the cooperating countries.

Finding the Earth's True Shape

In conjunction with other surveys the IAGS triangulation has created along the west coastline of North, Central, and South America the longest measured line in the world. It will run from Point Barrow, northernmost tip of Alaska, to the southern end of Chile, a distance of more than 11,000 miles.

This long arc of triangulation will eventually lock the maps of North and South America into a unified whole. But it will also serve another purpose: It will provide scientists with valuable new data for determining the shape of the earth.

Approximately every 150 miles along this line, geodesists have set up astronomical observation points called Laplace stations (after Pierre Simon Laplace, a French mathematician). They set their instruments, normally, atop triangulation stations whose positions are already established.

At each Laplace station, latitude and longitude are redetermined by astronomy, using instruments far more precise than Dave Phillips's jungle astrolabe. After they have been checked and rechecked, the resulting figures are compared with those found earlier by triangulation.

The two sets of figures never agree. The astronomical position always comes out farther north or south, farther east or west, some-

An IAGS Student Practices Surveying on a Photograph

To help Latin Americans make accurate maps of their own countries, IAGS maintains a cartographic school in the Panama Canal Zone. Here in the last three years 227 students from 17 countries have learned subjects like geodetic surveying, astronomy, photogrammetry, drafting, and map reproduction.

Apprentice cartographers practice on all sorts of instruments. Student Angel Luján of Peru uses a Wilson photoalidade to measure angles between points in the photograph exactly as if he were on the spot where the camera stood.

times by thousands of feet. This apparent error is not the fault of the engineer or his instruments, but of the earth itself. Before he looks at the stars, the surveyor carefully levels his instrument so that he will know at just what angle it is pointing into the sky. His leveling, of course, is always done in reference to the ground beneath his feet and to the pull of gravity.

Any irregularity in the earth's surface at or near his Laplace station makes itself known as what scientists call a "gravity anomaly," which means simply that the direction of gravity's pull at that spot is deflected from the vertical. This, of course, spoils the surveyor's aim with his telescope and causes an error in his calculations when he determines his latitude and longitude.

The amount and direction of this error are what the geodesists need to know in order to figure out the shape of the earth. Working backward, they can calculate just what kind of a kink or bulge in the geoid must have caused it. And using data from hundreds of Laplace stations in a line stretching nearly from pole to pole, they will end up with an accurate picture of the earth's over-all curvature.

"An important thing to remember about the IAGS," Colonel Robertson told me, after I had seen its work going on in five countries, "is that we are not mapping Latin America. We're helping the Latin Americans to do it themselves. It's their program. We offer suggestions, we lend equipment and give technical advice. The rest is up to them.

"You get our engineers working with Chilean or Colombian or Guatemalan or any other Latin American engineers and they become friends. They stick together on a project for months or years and really get to know each other. Our men learn Spanish, the others learn English. They get to like each other and, even more important, they come to respect each other.

"Imagine this going on in 17 countries, on half a dozen or more projects in each country, year after year. You can see what a terrific thing it is for furthering inter-American relations."

Fossils Lift the Veil of Time

In These Telltale and Often Beautiful Relics of Vanished Ages, Science Reads Life's Story and Finds a Key to Mineral Treasure

By Harry S. Ladd and Roland W. Brown

U. S. Geological Survey

ASK the man in the street what a fossil is, and he'll say it has something to do with dinosaur bones. He's partially right, of course, but there is more to fossils than that. Fossils are patterns in life's broad tapestry, significant relics of that long past which has made the present possible.

As for dinosaur bones, you will see them dramatically mounted when you walk into the United States National Museum of the Smithsonian Institution in Washington, D. C. Upstairs, where our offices are, most of our study specimens obligingly squeeze into the shallow trays of cabinets that line the walls. One of us, Roland Brown, specializes in plants. Harry Ladd concentrates on spineless creatures of the sea—mollusks, corals, and so on. That doesn't mean we don't collect other unusual and fascinating things.

Finds Oldest Fossil Palm

Fossils answer many questions about the world's dim past. For example, Brown tells of a recent find that extended our knowledge of flowering plants by fully 10 million years.

It was September, 1953. I had just completed my summer field work out west, and on my way back to Washington I dropped in at the Denver office of the U. S. Geological Survey. Something was in the air. I could tell by the way Dr. G. Edward Lewis, vertebrate paleontologist, greeted me.

"Brownie, I've got something to show you!" he exclaimed. Lewis, tall and wiry, was obviously excited.

"What's it all about, Ed?" I asked. "Got a new dinosaur by the tail?" I knew that he had been exploring deposits from the Triassic period in southwestern Colorado. These red sandstones, laid down by streams in ages past, were known to contain fossil reptile teeth. Lewis had been hunting skeletal remains of the original owners.

My friend only grinned and waved me to follow. In his office, fossils not yet classified cluttered a table. He selected a rock sample and ripped off its burlap cover.

"Take a look at this," he said.

A large, fragmentary leaf imprint showed on the red sandstone slab. None of the original substance remained. Except for the broken edges, however, the details were so perfect that the mold might have been made in colored plastic or concrete the night before. The ribbed structure was unmistakable.

"Ed, you've got a palm," I said.

"How can that be? It's from the Triassic, and no one's ever found a palm dating back that far!"

Tip and stem were gone, but I could see the resemblance to leaves that appear first on the seedlings of all living palms. Yes, this was a palm, or its immediate progenitor. An important find, bearing on the origin of modern plants.

"Do you have any more like it?" I asked.

"This is all I've come across," he said.

The next summer I returned to Denver to continue the search. Lewis and I jeeped back into the rugged, semiarid terrain around Placerville, Colorado. Here the San Miguel River cuts the painted west slope of the San Juan Mountains. Birches, willows, and cottonwoods line the stream banks. Piñon and spruce forest the higher reaches.

Lewis and I pushed through clumps of juniper, skunkbush, and scrub oak. We clambered up steep, crumbling slopes to where rock outcrops punch red holes in the canyon's scraggly green cloak. What a story these rocks had to tell!

When Dinosaurs Were Young

When the red beds were formed, some 165 million years ago, no mountains thrust jagged crests skyward where the San Juans now stand. There was only a featureless plain. Stubby-tailed amphibians peered out from sluggish streams; crocodilelike phytosaurs crawled among ferns and rushes. Dinosaurs—as yet small and slender, not the terrible beasts they were to become—ran two-legged across the monotonous landscape. Only the most primitive mammal progenitors trod the earth. No dragon soared on leathery wings; no feathered bird had seen the light of day.

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Kodachromes by Staff Photographers Robert F. Sisson and Donald McBain

A Palmlike Plant Left These Imprints on Colorado's Red Rock 165 Million Years Ago

Fossils, the hands on eternity's clock, reveal the pageant of life through the ages. This specimen predates other known flowering plants by about 10 million years. Flowering plants that enclose their seeds in a protective ovary dominate modern vegetation. Primitive spore bearers such as ferns represent the old order. Co-author Roland W. Brown points out the leaf's ribbed structure to Dr. Alexander Wetmore, Research Associate of the Smithsonian Institution and a Trustee of the National Geographic Society. The plant's discovery is here announced for the first time.

In imagination's eye I reviewed the cycle of life that ends in cold stone but retains the beauty of living matter—fossilization.

Palmlike trees flank a meandering stream, their young top leaves green with vital chlorophyll. Spent leaves, withered and brown, hang listlessly along the stems. A warm breeze loosens a dangling leaf and drops it into the gently moving water below. At journey's end in a quiet pond it sinks to the bottom. Silt and sand imprison the tough brown frond in darkness. Warm summer slips into cool autumn. As seasons come and go, layers of sediment bury the leaf deeper. Bacteria destroy the tissue, but not before the leaf impresses its form on the hardening mud.

Hunt Rewarded by Six More Palms

Pressure turns the mud to rock. Earth movements over millions of years lift high the buried life of the pond. Slowly, endlessly, relentless elements and the San Miguel River chew away the mountain shoulder, baring an edge of the ancient pond floor. A paleontologist cleaves the ancient rock and, through sheer luck, reveals one of Nature's miracles—a living leaf transmuted into a stone impression by "the patient alchemy of the ages."

Searching at 300 feet or so up the San Miguel slope, I uncovered six imprints, all more complete than the one Lewis had found. The largest was 18 inches long (page 380).

Back at the Smithsonian I catalogued the new specimens, comparing them with other fossil palms arranged in trays according to geological age and location.

Even with the tip missing, the Colorado leaf was clearly elliptical (opposite). The other palm leaves were fan-shaped. Many samples came from the Cretaceous period, beginning about 130 million years ago, when flowering plants—the admirably adapted angiosperms which were eventually to forest the continents—began to dominate the older and more primitive mosses, ferns, horsetails, and other now-extinct plants. The Jurassic period, commencing some 155 million years ago, yielded fewer specimens of flowering plants. The Triassic, none.

Turning to the library, I found that the oldest known specimen of a flowering plant came from the Jurassic of Normandy. The new find was at least 10 million years older!

Fossil collecting is not only exciting, it can be downright dangerous, as some of our predecessors discovered. Pioneer surveyors in the wild West kept one eye on the outcrops, the other on the Indians. They needed more soldiers than geologists, packed more rifles than rock hammers.

Harry Ladd is not sure those days are gone.

"They weren't when I was mapping for an oil company in South America," Harry recalls. "It was jungle country, remote and wild—the Barco Concession in Colombia. Motilone Indian territory. They're the most savage and dangerous Indians alive.

"Hiking along rivers or hacking a jungle trail were the only ways we could get about. Armed guards stood by while I cracked stream ledges looking for fossil mollusks. Hard keeping my mind on fossils, especially when I got to thinking about the geologist killed in an ambush a short time before."

An ivory-tower life? Hardly. Paleontology calls for rugged field work in addition to the quieter, and equally necessary, disciplines of classifying and interpreting the fossils we uncover. Sometimes we find just the fossil we're looking for. At other times our discoveries are by accident, as when Lewis's search for reptile bones threw new light on the origin of modern plants. Each forward step we make furthers the work of generations of scientists before us.

Strange Fossils Excite Curiosity

Agricola, the 16th-century German "father of mineralogy," gave currency to the term "fossil" (from the Latin *fossilis*—dug up), but these strange objects had long excited man's curiosity. Anaximander of Miletus, an Ionian Greek who lived in the 6th century B. C., was among the first to perceive their true nature. Struck by seeing lifelike stony fish embedded high above sea level, he concluded that they had once been living creatures. Surprisingly, he further believed that mankind had descended from fishes.

The great historian Herodotus, on the other hand, explained the coinlike fossils in Egyptian limestones as petrified lentils, food discarded by slaves who built the pyramids. To the Roman naturalist Pliny, a fossil shark's tooth was glossopetra (tongue-stone), which "groweth not upon the ground, but in the eclipse of the moon falleth from heaven."

Through the centuries fossils were fancifully explained as due to the action of the stars, or developed by fermentations. Some said they were freaks or sports of nature. Others thought them the work of evil spirits.

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Staff Photographer B. Anthony Stewart

↑ Once This Palm, Now Brittle Stone, Swayed to Caribbean Breezes

The petrified palm came from Antigua. Marine sediments buried the speckled bird egg (left) on a Fiji island. There it remained some 30 million years, with shell essentially unaltered, until excavators returned it to a world no longer inhabited by its species.

↓ Tree Limb (Left) and Reptile Bone Glow Like Gems—They Are Opalized

Australia sent the vertebra of a plesiosaur (right). This swimming reptile became extinct about 60 million years ago. Large specimens attained 40 feet. Nevada yielded the tree branch. In both cases petrifaction replaced organic material with opal.

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David S. Boyer, National Geographic Staff

Co-author Harry S. Ladd and Son Inspect Wood Mineralized by Carnotite

Thirteen-year-old David's fossil collection includes mastodon tooth, dinosaur vertebra, carbonized leaf, and fishes.

Through the mists of superstition, men groped toward a fuller understanding of their planet. Observing natural forces at work about them, they found rational explanations that helped unravel the story of earth's formation through the ages.

Men drew lessons from the delta-building Nile, from once-flourishing ports stranded high and dry, from mountain-gouging torrents that turned fertile brown fields into gray eroded wastelands. They heard the cracking of desert rocks as chill night followed burning day, they choked in whirling dust storms, saw earthquakes shatter cities, knew the unleashed fury of Vesuvius and Etna.

No, this was not the static, unchanging world some ancients thought.

Water Conquers Mountains

Avicenna, 11th-century Persian Arab philosopher, declared that water sculptures and wears away mountains. From fossil remains he deduced that some strata perhaps originated in a sea that had overspread the land.

Leonardo da Vinci, whose work as sculptor, architect, engineer, and canal builder taught him about the rocks of northern Italy, denied that fossils found in the Apennines were carried there by rising waters of the Flood. They were, he said, salt-water creatures buried on the sea floor by river-borne mud that formed layers of rock eventually uplifted to mountain heights.

Each new fossil discovery made it more apparent that the earth once nurtured forms of life not upon it today, that major climatic and geologic changes had occurred long before man stepped into the scene. Time, however, was the roadblock. Had not the learned Archbishop Ussher of Ireland proved that the world began "upon the entrance of the night preceding the twenty third day of Octob." in the year 4004 B. C.?

Scholars labored to reconcile new facts with old theories, but concept after concept crumbled before the onslaught of new findings, new insights. The horizons of time were pushed back, first by thousands, then by millions of years. Yes, forces presently revamping the world's surface *could* account for previous changes—given enough time.

Time for earth's crust to bend and crumple; for mountains to rear as high as 30,000 feet at the rate of an inch or so a century, then be worn to stumps by angry rivers. Time for land connections to rise, then disappear into the ever-changing sea, sealing off faunas in continental isolation. Time for world climates to ebb from hot to cold; for glaciers to grind and scour, then draw back to polar retreats, leaving rounded boulders and gravel heaped as if by some aimless giant.

It all took time. More than three billion years, according to latest estimates based on known rates of decomposition of radioactive elements in the earth's crust.*

Still there remained the puzzle of life. When and how did it begin? What gave rise to the tremendous variety of plant and animal life? Why did some species survive and others not stand the test of time?

In his study of fossils, man's restless, inquiring mind found the clues, for through fossils alone can we visualize the far-distant past and trace life's evolution.

Paleontology—the study of past life through the fossil record—matured into a science about 1800 with the work of Baron Cuvier, trail blazer in vertebrate zoology; the Chevalier de Lamarck, first modern invertebrate zoologist; and the English geologist William Smith.

Fossils: Calendar of Life

Smith found the time key to the rocks in the succession of life forms recorded by fossils. By arranging fossils in a standard column, the paleontologist can unlock the dating secret for any surface outcrop or subterranean drill core containing recognizable plant or animal remains. Since Smith's concept is basic to understanding earth science, let us give an example of the way it works.

Imagine two stacks of concrete slabs piled on opposite sides of a yard. Each slab represents a layer of the earth's crust; each pile symbolizes a separate region. The slabs are stacked in the order in which each layer was laid down, with the oldest at bottom.

All would be quite simple if they remained in that order throughout earth history. But earthquakes shatter the right-hand pile; subterranean pressures arch some pieces, stand others on edge, slide some above others, turn some over. The original sequence is lost.

How do you determine the original order of the scrambled formation?

The layers were indistinguishable from one another at the start, with this important difference: red pebbles were imbedded in one,

* See "Our Home-town Planet, Earth," by F. Barrows Colton, National Geographic Magazine, January, 1952

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Staff Photographer Willard R. Culver

↑ **Ages Have Not Dimmed the Luster of Coiled Ammonites**

Dipped in water, these extinct relatives of the pearly nautilus seem to take fire. Navajo medicine men value them as charms. Paleontologists find them a key to earth's time secrets. Some ancient shells exceed six feet in diameter, a record for coiled mollusks.

↓ **Jawbone Tinged with Green Belonged to an Ice Age Rabbit in Arizona**

Copper solutions stained the bone (three times natural size). Lower left: *Neritina*, a fossil snail from the Caribbean, retains its original black and white. Right: *Cranaena*, commonly called lamp shell, has preserved its maroon bands about 390 million years.

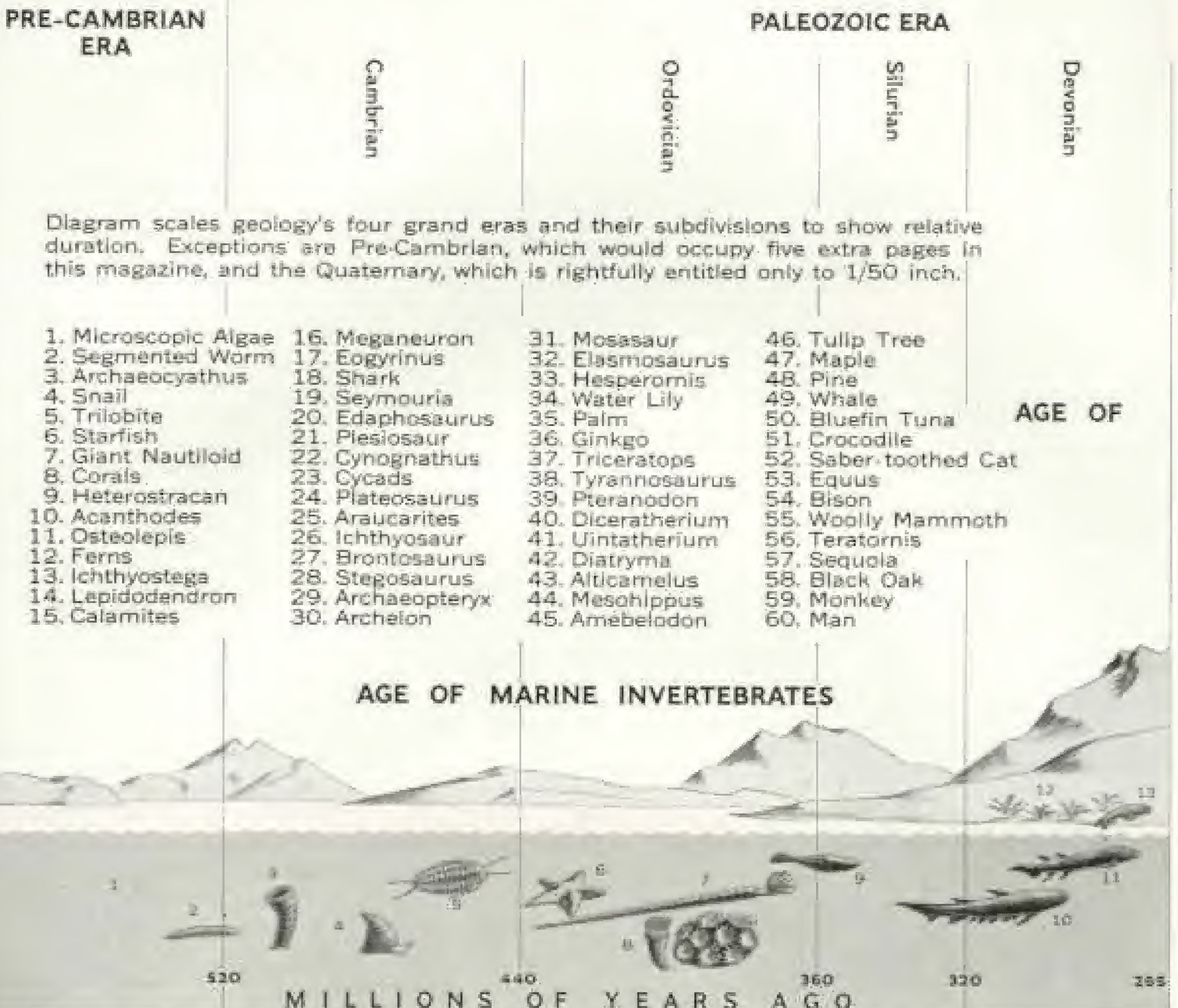

Diagram scales geology's four grand eras and their subdivisions to show relative duration. Exceptions are Pre-Cambrian, which would occupy five extra pages in this magazine, and the Quaternary, which is rightfully entitled only to 1/50 inch.

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green in another, and so on—just as certain distinctive fossils characterize different periods in earth history. So you simply compare the sequence of pebbles in the untouched pile of slabs with those in the shuffled pile and you have your answer.

From the fossil sequence Smith used, Cuvier and his disciples theorized that each successive fauna flourished, met catastrophic extinction, and was replaced by animal migrations from unknown regions and by independent creations.

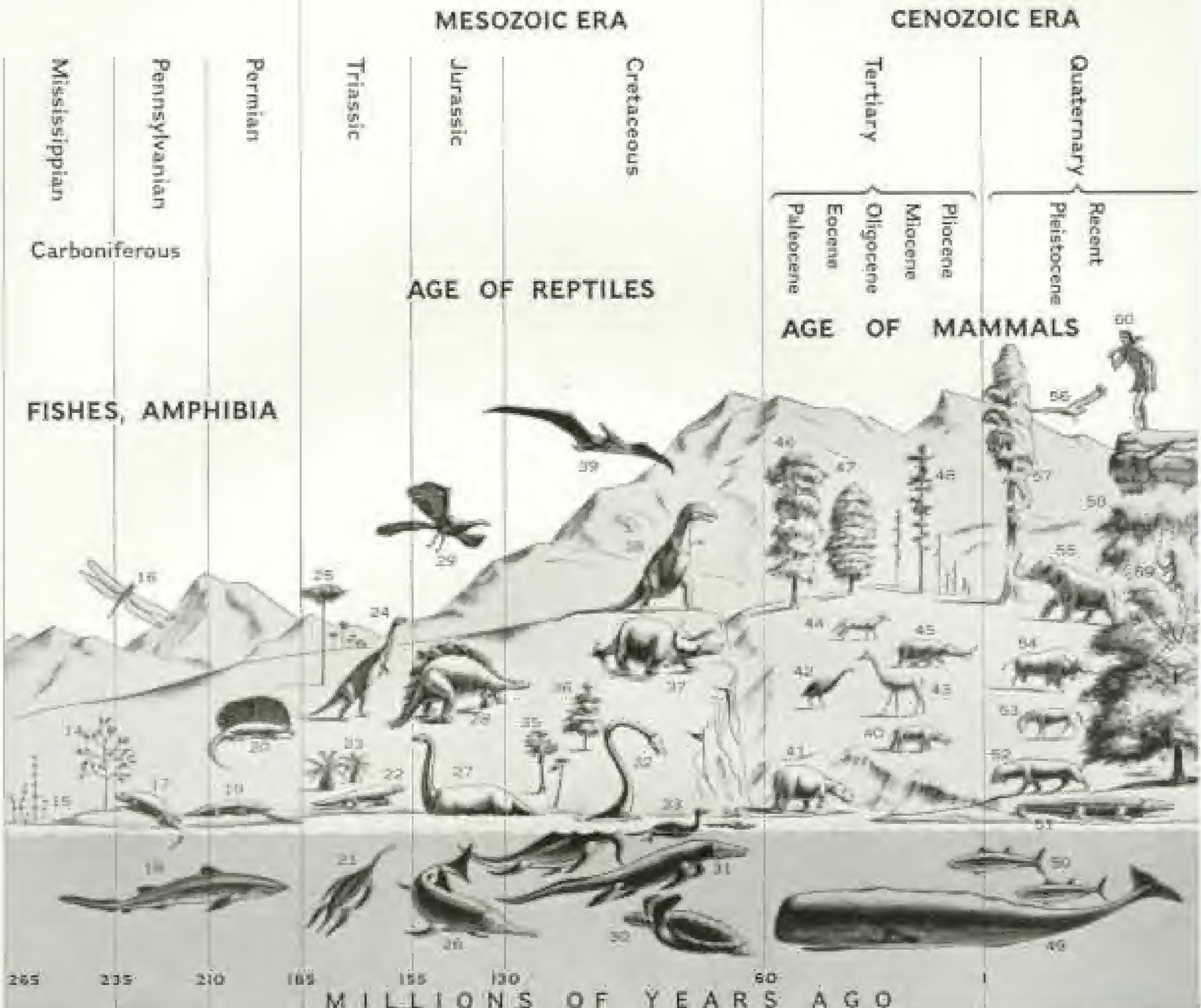
Lamarck, however, saw in the fossil record a continuous, purposeful progression of lower orders into higher. It remained for Darwin to re-emphasize Nature's economy in creation, and by his theory of natural selection to explain the origin and evolution of species—from primitive invertebrates to man; from simple algae to the spreading chestnut tree.

That there are large gaps in the fossil record, no paleontologist will deny. A few jigsaw-puzzle pieces joined here, a few there, reveal a pattern, but large areas remain blank, including the whole bottom of the scene.

"The Book of Ten Thousand Volumes," as certain Chinese villagers call the earth's bedded strata, begins its story of life with a glimpse of shallow Cambrian seas some 500 million years ago. Sea worms wriggle among the sponges. Shrimplike animals dart past lazing jellyfish. The trilobite—like a flattened, pincerless lobster in jointed armor—scavenges with waving antennae along the muddy bottom where seaweeds undulate in the currents (page 381). It is a picture of life already far up evolution's ladder. Obviously life must have existed on earth much longer than this fossil record shows.

Science Yearns for Vital Link

Why do Pre-Cambrian rocks almost never yield clearly identifiable animal remains? One reason is that heat and pressure through untold centuries have changed the rocks' texture. This almost always destroys fossils.



Drawing by John W. Lothers

Some algae and fungi, perhaps two billion years old, also a few sponges, brachiopods, arthropods, and wormlike trails and burrows have been found—and that's about all. This fragmentary chapter contains the most significant part of life's story. Small wonder that young paleontologists dream of unearthing on some unexplored island or remote continental tract a fossil sequence that will show how protozoans evolved into trilobites!

Like an underwater camera, the fossil sequence records the kaleidoscopic life of Cambrian seas, then moves on to parade primitive jawless vertebrates, hideous scorpionlike creatures eight feet long, and fantastic armored fish. Old species become extinct, new ones rise to dominance.

Plants invade the gray barrens of the continents. Sharks and bony fishes battle in the oceans. A footprint in Devonian sands records the dramatic moment, some 300 million years ago, when a lunged amphibian ventured out on a land now mantled with green.

♠ Life's Endless Miracle Parades Out of the Mists of Time

For ages after earth was born, there was no life. Creation's first stirrings took place in warm primeval seas, but wrote no record in the rocks. Tiny one-celled algae and fungi left the earliest evidences of life some two billion years ago.

The fossil story remains almost blank until the Cambrian, half a billion years in the past. Marine invertebrates (figures 2 through 8) were already well developed by that period; they live on today in countless species of sponges, corals, worms, mollusks, and crustaceans.

First vertebrates were the fishes (9-11), progenitors of the amphibians (13), whose lungs and limbs enabled them to waddle out on land. Dinosaurs (27, 28, 38), descendants of the amphibians, grew to giant size, only to become extinct, but crocodiles (51) survived, as though evolution had stood still.

Birds (29) and reptilian pteranodon (39) with its leathery 27-foot wingspread evolved from related cold-blooded stock. Mammals branched off from the reptiles in the Mesozoic. Whale (49), the largest, and man (60), the brainiest of mammals, appeared in the Cenozoic, the era in which we live.

Paralleling animals, the vegetable kingdom evolved from primitive seaweeds (1) through ferns (12), cycads (23), conifers (25), and flowering plants (35).

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Staff Photographer J. Baylor Roberts

Nature's Open Book: Uplifted Strata Reveal Chesapeake Bay Life of Bygone Ages

These fossil-rich cliffs stretch nearly 30 miles along Maryland's western shore. The authors inspect a whale vertebra. Inset: Tooth of a giant shark, extinct *Carcharodon megalodon*, terror of the Miocene seas.

About 185 million years ago we enter the Mesozoic Era, the Age of Reptiles. Dinosaurs rule the land; giant pterodactyls soon take to the air, plesiosaurs and ichthyosaurs to the sea. From the lithographic limestone quarries of Bavaria comes fossil evidence of the first feathered bird, *Archaeopteryx*.

The dawn of the Cenozoic, some 60 million years ago, ushers in the Age of Mammals, culminating in the development of man, whose existence on this planet has been but a minute in the time scale of eternity.*

Fossil Pearls Like Musket Balls

What does this fossil record include? Everything from dinosaur bones to the molds of nearly formless jellyfish, from bacteria to the trunks of forest giants; occasionally the nearly complete remains of an animal. Worm burrows, animal tracks, sand ripples, the trace of raindrops on mud flats—all these tell a story. Bone tumors, fractures, arthritic joints, pierced but partly healed skulls, evidence of violent death on every hand reveal that prehistoric animals had their problems too.

Amazing things have been preserved. We have the comb from a wasp's nest, the larval chamber of a mining bee, the egg capsule of a fish, the impression of a bird's feather—even the imprint of a human foot. There are fossil pearls that look like rusty musket balls, and a spider that died while producing silk threads. The spider's preservation in Baltic amber is so perfect that each thread can be traced under the microscope to the corresponding spinning tube.

Biologists estimate that there are at least a million species of living animals and several hundred thousand species of plants. Countless individuals represent each species, and the total of their ancestors back through the ages staggers the imagination. While the probability of any given animal or plant becoming a fossil is extremely remote, only a small fraction of earth's inhabitants need be preserved to present us with an impressive record of the evolution of life.

Visit the seashore at ebb tide and you cannot fail to be impressed with its abundant variety of life. Seaweeds, mollusks, scuttling crabs, and flowerlike anemones, the fish darting about the tide pools—all attest to the teeming life of shallow seas, where fossils are even now in the making. So it was when earlier seas spread inland and buried plants and animals in their sediments.

If the creature has durable parts such as bones, teeth, or shell, fossilization is simplified. Still, the chance of its thus achieving immortality is a million to one. The chances of its being found by man are even less.

Many rich fossil beds lie deep in the earth's crust, sealed from man's prying eye. Without destroying the precious cargo of fossils, Nature must accommodatingly raise the shale, limestone, or sandstone beds, tilt them, heave and buckle them into mountain peaks, or carve them into valleys and canyons so we can get at them. That is why, paradoxically, when we seek the floors of early seas, we must often go to the mountains.

You would hardly consider dry-land reaches of the Wyoming Rockies an angler's paradise; yet fine trophies—beautiful skeletonized fossil fishes on light shale—have been taken from valley walls near the whistle stop called Fossil, west of Kemmerer.†

Peccary Bones in Maryland Cliffs

A good place to find younger fossil-bearing strata is along present coastlines. Such are the Calvert Cliffs on the western shore of Chesapeake Bay, a handy 30-odd miles from our Washington, D. C., headquarters. Here waves undercut the uplifted remnants of an old sea bed. Storms tumble down huge blocks. These disintegrate, strewing the beach with relics of some 20 million years ago.

In these Maryland beds we have found mollusks, corals, barnacles, sand dollars, sharks' teeth, the remains of porpoises and whales, as well as the bones of peccaries and other land animals washed into the sea (opposite).

How many people realize that fossils not only reveal the past but are basic to our present industrial society? Coal, oil, the limestone essential to steelmaking—all three are of fossil origin. Energy from sunlight, imprisoned millions of years ago by plants, is released when coal and oil burn. Coal is the accumulated, digested, and compressed vegetable debris of swampy lands. Oil is decomposed plant and animal life from ancient sea basins; limestone, an accumulation of the skeletons of marine invertebrates.

The tiny "foram" is just one of many fossils

* See, in the National Geographic Magazine: "Parade of Life Through the Ages," by Charles R. Knight, February, 1942; and "Ice Age Man, the First American," by Thomas R. Henry, December, 1955.

† See "'Compleat Angler' Fishes for Fossils," by Imogene Powell, National Geographic Magazine, August, 1934.

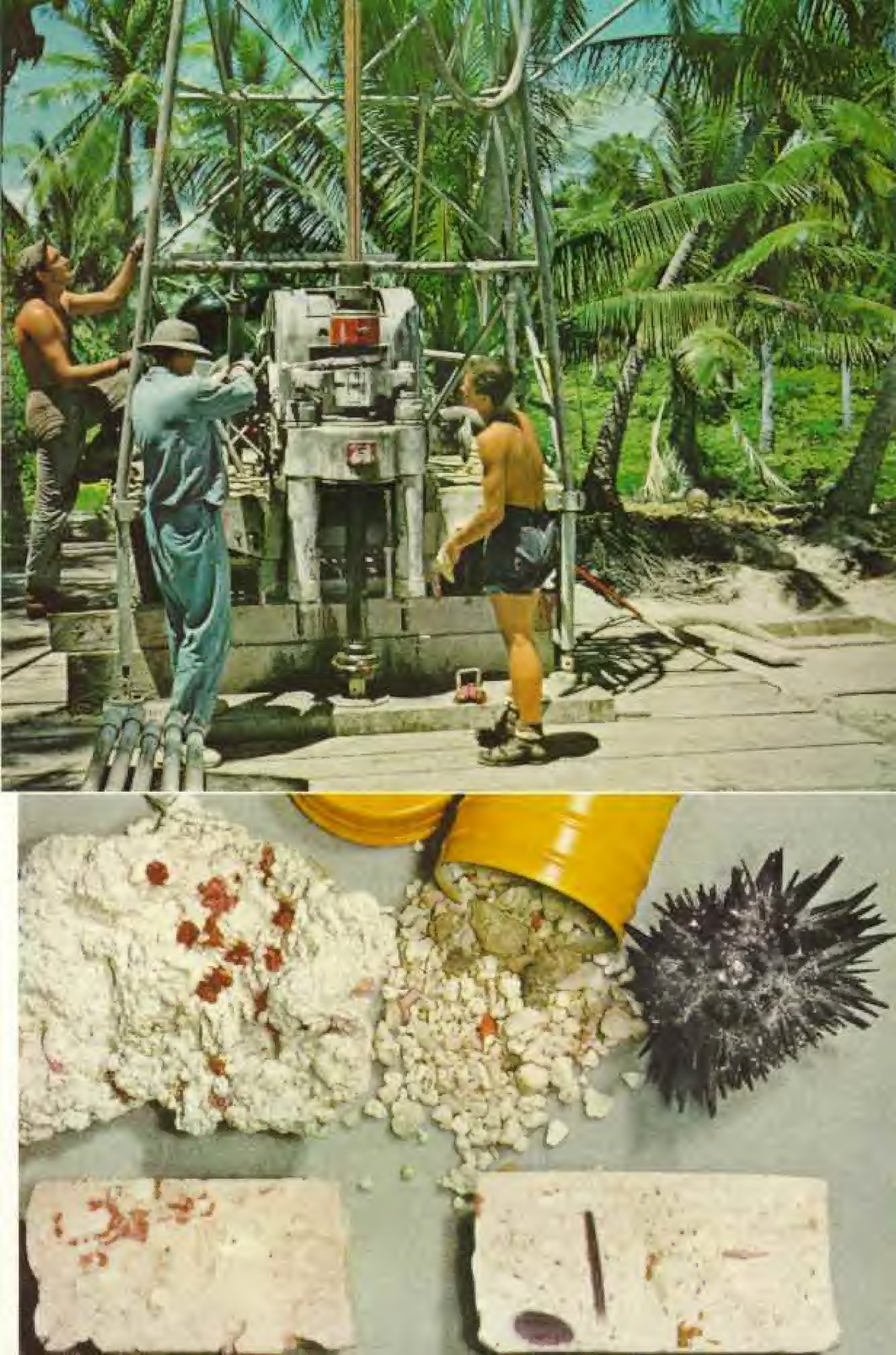
↑ Geologists Drill to Bikini's Depths

Bikini Atoll, atomic testing ground in the Marshall Islands, felt the bite of a rotary core drill in 1947. Dr. Ladd and a team penetrated 2,556 feet through coral limestone. Five years later, on near-by Eniwetok Atoll, Dr. Ladd and associates struck hard volcanic rock at 4,154 feet.

Upper left: A technician examines drill cuttings from Eniwetok. Some of the fossils found there are 40 million years old. ← Fragments of organ-pipe, blue, and branching coral (top) appear amid drill cuttings.

Page 375: Encrusting Foraminifera show red in the reef rock and core section at left. Spines of purple sea urchin color sample at right. A whole urchin rests beside cuttings.

© National Geographic Society
Staff Photographer B. Anthony Stewart and Joshua I. Tracey, Jr. (composite photo)



that aid in the discovery of mineral wealth. This protozoan is a veritable work horse in the oil industry.

Here the special science of micropaleontology has come into its own, for many plant and animal remains recovered in drill cuttings are so minute they must be studied under powerful microscopes. The limy skeletons of Foraminifera (forams) litter the floors of ancient seas. Specific forams trademark particular strata. Thus they help map subsurface oil-bearing deposits. By comparing the forams extracted from one drill hole with those from others, the oil geologist can tell the drillers whether they have reached a level that may yield oil.

Fossils Gleam in Rainbow Hues

The useful fossil also can be a thing of beauty. The geologist numbers among his most valuable signposts the highly ornamental ammonites. These iridescent ancestors of the poet's "ship of pearl," or nautilus, took many forms: straight, partially coiled, spiral. Many were shaped like rams' horns (page 369). Their flashing colors are caused not by pigment but by the prismatic properties of the shell's thin outer layer of mother-of-pearl.

Fire marble, also known as lumachel or shell marble, is another example of the preservation of nacreous luster. When tilted or viewed from different angles, the polished surface gives off scattered spots of brilliant rainbow colors from enclosed mollusk shells that have retained their sheen (opposite).

Fossil shells seldom match in gaudy colors the sea shells that collectors gather from our beaches today. Nonetheless, the small striped brachiopod, or lamp shell, we have from the Devonian seas of Iowa is a most unusual fossil (page 369). Its maroon bands have lasted some 290 million years.

The chemistry of shells has much to do with their retention of color. Whereas most shells and corals are made of a soluble calcium carbonate called aragonite, shells of the snail *Neritina* keep their color because their outer coat is relatively insoluble calcite. Specimens in the National Museum sport their black-and-white patterns as freshly as when they lived along the shores of a Caribbean island 17 million years ago (page 369).

These rare colors from the past provide the paleontologist with clues to early environments. Knowing that today's brightly colored shells are confined to shallow waters, we find colored fossil shells helpful in tracing the configuration of vanished seas.

Honors for the oldest known fossil to retain traces of original color pattern go to the trilobite. The 500-million-year-old specimen from Cherokee County, Alabama, consists of a tail segment striped in light and dark gray and spotted yellow.

Other unusual fossils take on a secondhand coloration from some mineralizing solution. More than 50 minerals produce fossil colors, ranging from drab dolomite and chert to the fire opal's radiant hues. The striking reds, browns, yellows, and greens displayed by silicified wood in the Petrified Forest National Monument in Arizona come mainly from compounds of iron and manganese (page 385).

Bright-hued fossil wood always attracts attention. Indians shaped it into arrowheads. Modern Americans fashion it into decorative book ends, paperweights, jewelry, and fireplaces. Now that the Atomic Age finds men with Geiger counters and Scintillometers swarming into little-explored areas of the southwestern United States, new fossil forests are reported from time to time. Uranium deposits here are often associated with fossil wood and dinosaur bones.

Uranium Hunter Finds Stone Trees

Lurt Knee, who steals time from his ranch near Torrey, Utah, to prospect for uranium, recently discovered a series of fossil forests in the badlands of Circle Cliffs. Soon after, Lurt guided photographer Josef Muench and his wife through rough but scenic canyon country to the site.

Here massive sandstone blocks cap softer, rainbow-colored strata. Amid erosion's rubble the party came upon ancient forest giants —stone logs 10 feet in diameter and 130 feet long. Eight and one-half feet of one great stump stood where it had grown (page 383).

Muench sent us samples of the unreported forest. Studying translucent sections under a microscope, Roland Brown matched the cellular structure of the Circle Cliffs wood with conifers in Arizona's Petrified Forest. Called *Araucarioxylon*, the Utah trees flourished 165 million years ago.

"It's 165 million and three years now!" quips Lurt Knee in a letter just received.

Prospectors for copper hit upon a deep fissure in the limestone near Anita, Arizona, that tells a later, Ice Age, story. An unwary rabbit bounded into the chasm and fell to the

← This Banded Limestone, Canada's "Dawn Animal," Sparked a Scientific Clash

In the alternate white and green bands of calcite and serpentine, Sir J. William Dawson, noted Canadian geologist, found microscopic evidence of what he believed to be the oldest known form of animal life. In the 1860's he named the fossil *Eozoon canadense* (dawn animal of Canada). His theory stirred a controversy that has continued to this day.

Dissenting paleontologists classified *Eozoon* as of plant rather than animal origin. They described the white bands as calcite left by blue-green algae, tiny seaweeds.

Other scientists contended that the ancient "fossil" was purely mineral—a product of the heat and pressure of metamorphism.

Today all sides agree on one point: *Eozoon* is not an animal colony of Foraminifera, as Dawson believed. A billion years old or more, it comes out of the Pre-Cambrian.

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Staff Photographers B. Anthony Stewart (left) and Willard R. Culver

Entombed Shells → Shine in Lumachel

This piece of fossiliferous limestone, also known as fire marble, comes from the province of Carinthia, Austria. When polished, its surface emits rainbow hues from fossil shells that have retained their mother-of-pearl sheen more than 150 million years.

Limestone, most often formed by the deposition of the skeletons of marine invertebrates, is chalk-white in its pure state. Color reveals the presence of impurities. Iron oxide, for example, may tint the stone brown, yellow, or red. Here the dark background denotes carbon.

Samples of silicified wood at bottom show the colors of other minerals. Left: Fossil oak from Washington State. Right: Spruce from Idaho.

G. Edward Lewis

A Geological Team in Arizona Drills Sandstone Cliffs for a Missing Link

In 1953-54 Dr. G. Edward Lewis and associates made a significant discovery. Quarrying in Monument Valley, they uncovered the New World's first known tritylodonts.

Spaniel-size tritylodonts, named for their three-cusped mammal-like teeth, appeared in the late Triassic and survived about 20 million years. On evolution's ladder they stood between the cold-blooded reptiles and the warm-blooded mammals (opposite).

bottom. Pleistocene horses, camels, woodchucks, pack rats, pocket gophers, squirrels, and a hyenalike animal likewise plunged into the death trap. Many of the broken bones found in the deep sand deposit at bottom were stained green by copper-bearing solutions (page 369). Some gopher teeth still show traces of their original orange color.

Ancient quicksands along Nebraska's Niobrara River exacted a fearful toll. One deposit, alone estimated to contain 17,000 dismembered skeletons, is literally paved with bones. Some belong to the strange claw-hoofed *Moropus*, remote relative of the horse; some to the giant tusked swine *Dinohyus*, six feet high with a yard-long skull. But the overwhelming majority belong to the small twin-horned rhinoceros *Diceratherium*.

Death of a Rhino Herd

This sign of mass burials evokes a picture of large herds of little rhinos, crazed with thirst, emerging from dusty alkaline plains to plunge into the river. As the bellowing beasts trample one another in futile struggle to escape, the bottomless morass chokes off lives one by one. Soon the silent shifting sands close over the last of the herd, vanished as though it had never been.

Perhaps thirst also triggered the amazing death cycle at the La Brea tar pits in Los Angeles. Standing pools of water may have lured a giant bison or a ground sloth across the concealed asphalt. The unwary animal breaks through. He fights the appallingly sticky asphalt, only to sink deeper. Lured by living bait, saber-toothed cats pounce and are trapped. Wolves and coyotes meet the same fate in turn. Vultures swoop down to feast on the carcasses. They jostle; a wing drops into the tar and another prisoner perishes.

On and on the cycle repeats, each newcomer a potential fossil, its bones to be preserved splendidly for thousands of years. More than 1,500 saber-tooth skulls alone have been recovered from the asphalt grave!

Lava flows normally wipe out plants and animals trapped in their paths. In Valencia County, New Mexico, however, vertical tubes with tree-bark markings on the inside pierce the solidified lava. They suggest that yellow pines were surrounded by the flow.

Near the Grand Coulee, Washington, a prehistoric rhinoceros was molded in lava. Geologists who discovered the remarkable fossil believe that lava flowed into a shallow body

of water containing the rhinoceros's bloated carcass. The still-plastic lava packed around the body, then cooled into a rigid mold.

Volcanic ash created the famous fossil beds near Florissant, high in the Colorado Rockies. Thirty million years ago the site was a lake whose shores and surrounding uplands were clothed with pine, oak, walnut, poplar, and many other well-known forest trees of today, topped by towering redwoods. Periodic volcanic eruptions buried parts of this forest. Stumps, leaves, and more than 600 species of flies, bees, bugs, beetles, grasshoppers, and rare butterflies were preserved in the ash. Rains that washed hillside mud into the basin helped entomb the life forms.

Today the lake sediments reappear in road cuts and ravines as soft pink shales that can be split into thin layers. Nearly every stroke reveals a fossil leaf, insect, or fish.

"Did you paint the leaf on there?" visitors to the National Museum often ask when they view a beautiful Florissant leaf delicately etched in black on the light-colored shale.

A denial of nature-faking brings further questions: "Why isn't the leaf red, yellow, or brown? What turned it black?"

First, we describe how the ancient leaf's natural color changed as chemical action reduced the silt-enclosed tissue to a residual film of carbon. Then we show one of our prize specimens, a 50-million-year-old leaf that looks as if it had fallen from a tree yesterday. Fossil records do not always alter through time, and we were able to peel such leaves intact from western Tennessee shale, preserving them between glass plates.

Peat is another good preservative of organic matter. During the past two centuries about 100 Iron Age and Bronze Age men have been dug out of peat bogs in northern Europe. Parts of some bodies are not even a bit

Five Tritylodont Skulls, 3 with Skeletons Attached, Come to Light After 155 Million Years

Some Old World tritylodonts had to be classified on the basis of teeth alone. These Arizona skeletons, supported by sand bags, were the first ever found (opposite).

G. Edward Lewis

Roland W. Brown

The End of a Search: Dr. Brown Frees Fossil Leaves from a Prison of Rock

In 1953 paleontologist Lewis took a fragmentary leaf imprint from this Triassic outcrop in Colorado. Here Dr. Brown confirms Dr. Lewis's discovery of the oldest known flowering plant (pages 364 and 365).

desiccated. On the face of Tollund man, discovered in Denmark in 1950, every wrinkle, every feature shows as clearly as on the day he was sacrificed in a tribal ceremony.*

Shaggy Elephants on Ice

In New York's American Museum of Natural History you can see another potential human fossil—"copper man," found in a Chilean mine shaft. This pre-Columbian Indian, clad in a waistcloth and using rough stone tools, was apparently killed at work underground. The copper skin color suggests that minerals entered it, but actually simple drying preserved the body.

In age, however, these finds pale before those made in cave deposits of Choukoutien, near Peking (Peiping), China, in the 1920's and 1930's. Known collectively as *Sinanthropus pekinensis*, Peking man, these fragmentary remains of some 40 individuals wrote a new chapter in man's early history.

Roughly contemporary with apelike Java man, beetle-browed, chinless Sinanthropus used fire and made crude implements of stone and deer antlers.

Safe in Nature's keeping some half-million years, Peking man disappeared during the Japanese invasion of China in World War II, and his whereabouts remain a mystery to this day. Fortunately, casts had been made of the priceless relics.

The most spectacular examples of fossilization are frozen woolly mammoths—the shaggy elephants that roamed over northern Europe, Asia, and North America during Pleistocene times. Doubtless most of these Ice Age longhairs decomposed or were devoured. Others bogged down in far-north swamps, froze in their dying pose, and kept solid thousands of years in Nature's deepfreeze.

Now, with a warming climate, their bodies and those of their contemporary, the woolly rhinoceros, are thawing out. Dogs and wild animals relish the still-red meat and white-to-yellow fat, and they suffer no ill effects. Siberian hunters bait fox traps with the flesh.

The Beresovka mammoth was retrieved from the Siberian tundra intact but for part of the exposed trunk devoured by wolves.

* See "Lifelike Man Preserved 2,000 Years in Peat," National Geographic Magazine, March, 1954.

The beast, evidently fallen into a crevasse, ruptured a blood vessel and fractured hip and foreleg in violent struggles to escape. Food still clenched between teeth told of swift death. The mounted tusker remains in the U.S.S.R., but we have samples of skin, muscle tissue, hair nearly 30 inches long, and stomach contents on exhibit at the U. S. National Museum.

Student Pranksters Fake Fossils

While it is hard to mistake a mammoth, there is a whole category of relics—"problematical fossils"—that brings out the detective in every paleontologist. These are unidentified fossils, often the subject of scientific dispute. Sometimes it is difficult to tell whether these bones of contention are animal or vegetable—indeed, whether they are fossils at all (page 377). Still others that resemble fossils but are clearly of inorganic origin we label "pseudofossils." A special category, of course, should be reserved for that prize howler, the Wedgwood teacup handle that was mistaken for the stem of a calamite!

Thirty years ago Harry Ladd was shown in an Australian museum a selenite crystal encasing the wing of a large insect. Assembling material for this article, the author recalled the specimen and wrote to the museum. The curator, obligingly making a photograph, noted that tiny air bubbles near the wing shifted position as pressure was applied to the crystal. Close study revealed that the crystal had been opened along a cleavage plane to take the wing. The "fossil" was a fake!

For the most incredible hoax of all, hear the sad tale of Johann Beringer, professor at Würzburg and ardent collector of fossils who often took his students collecting with him. In their zeal to enhance the professor's specimen cabinet, students began to carve weird stone images and plant them where he would discover them. The credulous Beringer showed such delight in his finds that the prank went on. As fast as the students carved, the professor gathered, until he had a truly unequaled display of wildly imaginative salamanders, flowers, insects, and astronomical objects.

Only when he had published his findings in an illustrated volume in 1726 did Beringer

Trilobites Mysteriously Became Extinct After a 300-million-year Reign in Early Seas

Long before fishes appeared, trilobites scavenged the ocean floor. Like their kin the lobsters, they shed outgrown shells. Their fossil remains comprise about half the known faunas of Cambrian times. These specimens in the National Museum show the distinctive three lobes that give the trilobite its name.

Staff Photographer John E. Fletcher

discover the trick. Humiliated, he spent every penny trying to buy back copies of his book. Ironically, after Beringer's death his family, to recoup their losses, reportedly reissued the work and sold it as a collector's item.

Why Scientists Study Fossils

Why do we devote our lives to collecting and studying fossils? Why resurrect the distant past? Why not let bygones be bygones?

First, there is the thrill of discovery, of finding new threads in the tapestry of life. What could be more fascinating than assembling the pages of earth's book in proper order through the study of fossils, the ancient script that tells so much about the world of long ago? This is purely a personal satisfaction, of course, but the paleontologist is aware of the value of this knowledge to his fellow man.

The biologist uses fossil evidence to illuminate his study of life's evolution, for classifying plants and animals, and for applications to biological, medical, and social problems.

Industrial and city planners, agricultural and military services need data on vital water and mineral resources from the geologic map maker; he in turn draws on fossil evidence when dating and correlating his strata.

The paleontologist often works on headline-making projects. In 1946-47 and again in 1950-52 Harry Ladd headed a geologic team at Bikini and Eniwetok Atolls, U. S. atomic testing centers in the Marshall Islands. While providing on-the-spot data for atomic physicists computing the effects of nuclear blasts, Ladd's team solved the mystery of how coral atolls were formed.

Volcano Rises from Sea Floor

They drilled two test holes on Eniwetok Atoll in 1952. For more than 4,000 feet the drills chewed into nothing but reef limestone. Then, at the bottom of this titanic mound, the bits struck hard basalt, the top of a volcano two miles above the sea floor.

This find confirmed the most important feature of Charles Darwin's theory that atolls develop on the tops of slowly sinking mountains. Eniwetok, for example, began as a reef growing on a volcanic mound. Slowly the volcano subsided, leaving only a ring of coral rock. Generations of coral polyps and calcareous algae worked 40 million years to keep the top of the atoll in shallow water as the foundation settled (page 374).

A discovery of value to pure science alone? Perhaps—but time and again what is pure science today has proved of vital practical concern tomorrow.

Dr. William E. Wrather, Director of the U. S. Geological Survey and a Trustee of the National Geographic Society, is well aware of this. He himself pioneered in the application of "didactic" micropaleontology to the Texas oil fields.

"Scientists had studied forams with no thought of economic advantage," Dr. Wrather recalls. "Micropaleontology was there, a pure science, waiting for someone to put it to commercial use. But it didn't happen overnight. I can remember when oil men hooted at anyone who examined drill mud with a microscope. Then came a day when Gulf Coast drillers wouldn't set pipe without a fossil expert at their elbow.

Map Makers' Task Never Ends

"It's the same with geologic mapping," Dr. Wrather continues. "We're not hunting for gold mines. That's not our business. We're studying earth history, an abstract science. But that doesn't mean someone won't be able to find some dollars-and-cents use for the information we uncover.

"True, the Survey has to keep pace with current needs. Topographic maps were made in Texas many years ago in areas where everything was cattle and mesquite. Look at some of those areas now. Towns of 15,000 and 20,000 and more. New problems of water. Oil wells. You simply can't see far enough into the future. A generation ago who'd have thought the world would be remade by atomic fission?

"Times change, a new demand arises, and you have to go back and refine your surveys for that changed purpose. No, you can never button up an area and say you're through."

To which we can only add: like geology, the study of fossils is never done.

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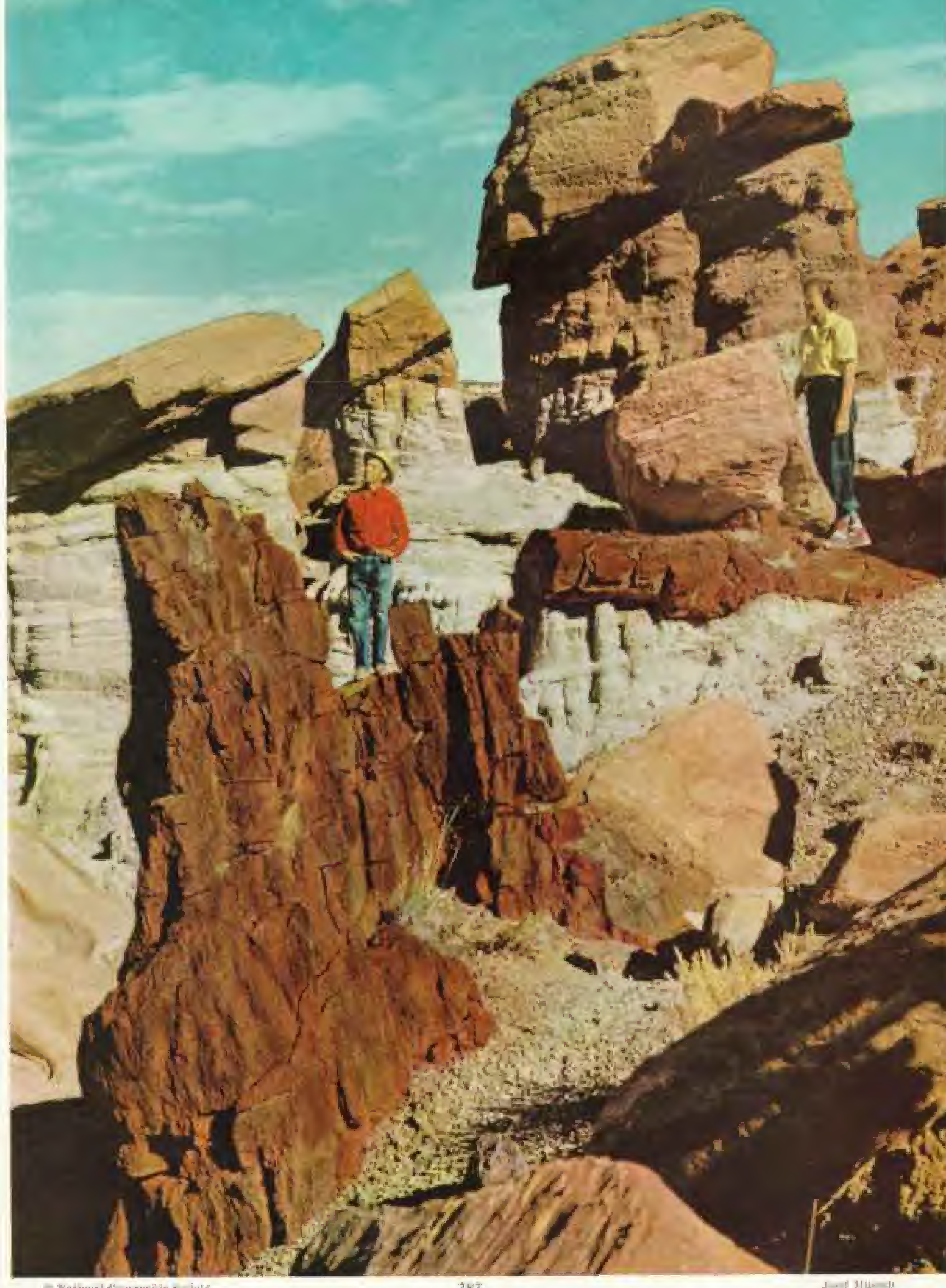

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Josef Muench

An Eroded Stone Stump Stands as Reminder of Utah's Ancient Sylvan Glory

Lurt Knee (left), a rancher whose Geiger counter "finds more scenery than uranium," recently made new finds in the petrified forests of the remote Circle Cliffs country. He stands on a once-towering conifer measuring 10 feet in diameter. Buried in mud and sand now worn away, its base has remained upright 165 million years.

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A Giant Tree from Ages Past Lies Rock-hard and Shattered at Utah's Circle Cliffs

Josef Muench

Inset: Metallic Fire Gleams in a Burnished Log from Arizona's Petrified Forest

© National Geographic Society

Staff Photographer B. Anthony Stewart

↑ Forty-niners Passed This Treasure By in Their Avid Search for Gold

Miners who washed the stream gravels at You Bet, California, for flecks of yellow metal ignored "worthless" hillocks of clay. But in them paleontologists found the imprint of a sycamore leaf. Its color developed in clay some 45 million years ago.

↓ Fossil Coral Presents Two Faces: a Mirror Study in Contrasts

This reef-building animal colony lived in warm Florida waters in early Miocene times. Reflected view shows the outer form preserved with silica that replaced the coral skeleton. Pencil points to structureless chalcedony that lines the interior.

People and Penguins of the Faraway Falklands

An Ornithologist Explores Britain's Remote South Atlantic Colony and Films the Life of the Islands' Feathered Sobersides

By Olin Sewall Pettingill, Jr.

With Illustrations from Photographs by the Author

FROM the rail of the steamer *Fitzroy*, as she plowed steadily toward the bottom of the world, we marveled at the spouting of whales and the long-winged gliding of albatrosses. Giant fulmars dipped and wheeled in our wake. The black-and-white wings of Cape pigeons made bold patterns against deep-blue water.

Then, hundreds of miles from any land, we spotted our first penguin—a small torpedo-like shape that suddenly broke the surface and then shot downward with incredible speed. It was hard to believe that this could be a bird—especially the dignified bird that always wears its formal evening clothes!*

"Noah's Ark" Links Colony to World

What better star for a Walt Disney movie than the feathered sobersides of the Southern Hemisphere? To film him on his home grounds for a new Disney True Life Adventure feature called "Islands of the Sea," my wife and I spent four months in the Falkland Islands, one of Great Britain's most remote outposts (map, page 393). Penguins and other birds outnumber the Crown Colony's 2,200 or so humans by many hundreds of thousands.

About 12 times a year the *Fitzroy* calls at Montevideo, Uruguay, to pick up passengers, mail, and freight for the Falklands, some 300 miles east of the Strait of Magellan and 800 miles north of Palmer Peninsula, Antarctica. The 855-ton ship is the colony's only regular link with the outside world (page 410).

Most of our 25 fellow passengers were homeward bound from holidays in England, returning with obvious joy to their island sheep farms and professions. To us it was remarkable that these cultured, well-dressed folk were happy to be sailing home to a bleak, treeless little world where a howling gale blows one day out of every five or six. On our voyage the *Fitzroy*'s cargo included sheep, some chickens, a few canaries, and a dog.

"She's another Noah's Ark," said the skipper, Capt. F. W. White.

Five days out of Montevideo, on a dark October night of wind, rain, and bitter cold, the *Fitzroy* deposited us and our gear on the jetty at Stanley, the colonial capital on East Falkland Island. Here true British reserve asserted itself; friends and relatives greeted one another as casually as if they had been separated for a day instead of months.

Bird Secrets Revealed

We were welcomed by Edwin M. Cawkell, the colony's Director of Public Education and an accomplished amateur ornithologist. After a short, rough trip in a jeeplike British Land Rover, we enjoyed tea before a peat fire in the Cawkell living room while we outlined plans for our film work.

On his official rounds during three years in the Falklands, Mr. Cawkell had visited even the most isolated sheep farms. Always he had found time for birds; he knew where the principal penguin colonies could be found and which were the most accessible for our purposes. He realized that we needed to live close to penguin colonies so that we could work with them day after day. This meant leaving Stanley for extended periods and

* See, in the National Geographic Magazine, "A Naturalist in Penguin Land," by Niall Rankin, January, 1955, and "Nature's Clown, the Penguin," by David Hellyer and Malcolm Davis, September, 1952.

The Author

A teacher of ornithology at the University of Michigan Biological Station since 1938, Maine-born Dr. Pettingill has also had a distinguished career as author, lecturer, and wildlife photographer. He has lectured for the National Audubon Society from the time the Audubon Screen Tours were instituted in 1945. Thousands of students have seen his instructional films of birds or used his college textbook *A Laboratory and Field Manual of Ornithology*. For the Audubon Society and the U. S. Fish and Wildlife Service, he made an intensive study of the whooping crane in 1945, and his findings aided in the fight to save this diminishing species from extinction.

All of the author's photographs illustrating this article are reproduced through the courtesy of Walt Disney Productions, since they were taken while on assignment to obtain scenes for a new True Life Adventure film, "Islands of the Sea." Many of Dr. Pettingill's sequences appeared in "Nature's Half Acre," "Water Birds," and "The Vanishing Prairie."

↓ **Sand Cabbage Brightens Falkland Beaches**

Though unrelated to the vegetable, *Senecio candicans* shares the cabbage's name because its leaves possess the same pale green color. Gay blossoms burst in December—early summer in the Southern Hemisphere.

© National Geographic Society

Heavy Surf Batters New Island's Cliffs

In colonial days New England sealers and whalers bound for Antarctica often stopped at New Island, westerly outpost of the Falklands. They left goats and pigs to assure a food supply on the return voyage.

Only three families live on New Island today. A whaling station on the island was abandoned in 1916.

Treeless moors suggest scenes in northern Scotland. Short grasses, mosses, and lichens cling to rocky slopes.

↓ Skuas Rear a Chick in a Seaside Nest

Bird life abounds in the Falklands. These gull-like birds nest near a penguin colony on New Island.

When baby demands food, his parents ambush a tender young penguin.

Skuas guard their own chicks zealously, giving battle to any intruder, human, horse, or dog. Attacking from the air, they sometimes strike with wings and bodies.

establishing bases of operation in the nearest buildings or farm homes. The greatest difficulty we faced, he pointed out, was transportation.

Travel by car in the Falklands is limited to the few roads in and around Stanley. Horseback, the chief means of getting from farm to farm on East or West Falkland, would not help us in going from Stanley to penguin colonies located either on small islands or on too-distant headlands.

As Falklanders are chiefly sheep farmers, not fishermen, most of them maintain no dependable seagoing craft. Our hope for transportation lay in three vessels—a Government hospital ship and two privately owned boats—and two Government floatplanes. Any one of them could be chartered.

Mr. Cawkell suggested that we go first to Charles Point, overlooking Port William, for gentoo penguins; then to Kidney Island, just outside Port William, for rockhopper and jackass penguins; and finally to privately owned New Island, on the western side of the archipelago, for larger colonies of the same penguins, plus black-browed albatrosses and many other birds.

Shaft Marks British Sea Victory

Next morning we caught our first daytime glimpse of the Falkland Islands. Through our bedroom window we looked into a small garden bright with spring blossoms. Below the flowers spread Stanley Harbour, lead colored and wave tossed, and beyond it barren hills rose to meet a sullen sky. An icy wind pressed against our window and shrieked past the house. We shivered, gulped our tea, and longed for our heavy clothing that was still in the *Fitzroy's* hold.

After breakfast we set out, the wind at our backs, for a tour of Stanley, a community of some 1,300 people and the only town in the Falklands. The Cawkell home was one of a number of dwellings for Government officials strung along Stanley Harbour west of the center of town. Near the neat houses, on a promontory, stood the memorial commemorating the Battle of the Falklands, a tall shaft of granite topped by a bronze ship model. Erected in 1927, the monument recalls an important naval victory for the British over the Germans in the outlying waters of the Falklands on December 8, 1914 (pages 395, 397).

Signing the guest book at Government House, we learned we were the first Americans to set foot in the colony in almost a decade.

In a small park between the Falkland Islands Company store and the Christ Church Cathedral we paused to look over an arch formed by the lower jawbones of two sperm whales (opposite). This was presented by the FIC in 1933, when the colony celebrated its centenary as part of the British Empire.

We devoted the next few days to reconnaissance jaunts over the adjoining "camp"—a term derived from the Spanish word *campo*, meaning countryside, referring to all the colony outside Stanley. Walking was not easy. If we were not skirting huge boulders or scrambling over rocky outcroppings, we were traversing stretches of tough white grass, sloshing through wet mossy places, or tramping across patches of diddle-dee, a low shrub and one of the very few native woody plants in the Falklands.

Now and then we passed bogs where Stanley residents had cut peat (page 398). Blocks of it, like huge chunks of chocolate fudge, had been piled up and left to dry.

We took a small boat from Stanley to Sparrow Cove where the rusty hull of a ship lay grounded, her masts silhouetted against the gray, rock-strewn slopes of Mount Low. This was all that was left of the famous *Great Britain*, probably the first propeller-driven iron ocean-going ship. Launched at Bristol, England, in 1843, she came to grief in a gale off Cape Horn in 1886 and barely made Stanley Harbour. Sold to the Falkland Islands Company, she served for 50 years as a storage hulk (page 403).

An Arch of Whalebones Commemorates → the Falklands' Centenary

Page 391: The Falkland Islands Company, a chartered firm, plays a major role in the islands' commerce. In 1933, when the Crown Colony celebrated 100 years as part of the British family of nations, the company built this monument from jawbones of two sperm whales. The arch overlooks the harbor at Stanley, the colony's capital and only town.

Gov. Sir Miles Clifford Reviews → the Honor Guard in Stanley

This ceremony preceded a meeting of the Legislative Council in the Town Hall at right. The building also houses the Falkland post office, library, and court chambers. Upper floor serves as recreation center for dances, concerts, and plays.

Bareheaded guardsman in rear rank lost his cap to the wind.

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Her days of usefulness finally over, the *Great Britain* was towed to Sparrow Cove and abandoned there in 1936. Stanley residents visit her occasionally, not to pay their respects to a great lady of maritime history but to gather from her weathered sides huge mussels, declared to be most tender and delicious.

In our wanderings we came upon the more common upland birds: trim winter plovers, black-throated finches attired in blue, green, and yellow, Falkland robins that look like a faded version of our North American species, and red-breasted troupials.

High above the most exposed ridges Antarctic pipits defiantly sang their tinkling flight songs while being tossed about by the wind. In the lee of cliffs and outcroppings phoebe-like ground tyrants sought insects.

Impatient to work with penguins, we began making preparations and purchasing supplies for life in the camp. One morning when the wind was more biting than usual, we boarded the Falkland Islands Company's *Stockfish*, a harbor-bound boat used primarily as a ferry between jetties and anchored ships. She bore us safely across choppy water out of Stanley Harbour and deposited us on the lee side of Charles Point, one of the most exposed headlands in Port William.

Our Charles Point camp, in an abandoned World War II military installation, overlooked Port William and the white sandy beach of Rabbit Cove. Even as we landed and made our way up the steep slope to our tin shelter, we could see a group of gentoo penguins loitering on the beach and a few others moving inland to their nesting colony, barely in view on a high knoll.

Penguins Leap Like Porpoises

For the next week we followed the daily routine of the gentoos. Although birds came ashore here all during the day, the majority appeared in the late afternoon. As a rule, they arrived in groups. We watched first one group and then another enter Rabbit Cove and come landward, each individual "porpoising" by alternately leaping gracefully out of the water and plunging below the surface.

Once near the shore, just as the surf began

to swell and roll, the birds remained submerged and, like torpedoes shot from firing tubes, headed for their objective with amazing speed. Exploding out of the breaking surf, they made their landings, sometimes on their bellies, sometimes on their feet, and stumbled forward.

As if embarrassed by their own clumsiness, they picked themselves up quickly and waddled self-consciously up the beach. There, beyond reach of the waves, they stopped to regain their composure, usually preened for a while, and rested briefly before the next stage in their return to the colony.

Though the gentoos' colony stood on a knoll only a few hundred yards from the sea, the path to it circled far inland. Used by countless generations of gentoos, the trail was well-worn and clearly marked.

← Stanley Streets Look Deserted

Strong winds keep residents indoors most of the time. Empty oil drums clutter the streetside.

↓ Falklands Guard the Road to Cape Horn

Capt. John Davis, an Englishman, discovered the islands in 1592. Great Britain annexed them as a Crown Colony in 1833, but Argentina still disputes British sovereignty. East and West Falkland, together with some 200 islets, almost equal Connecticut in size. South America lies 300 miles to the west, Antarctica 800 miles to the south.

FALKLAND ISLANDS

ARGENTINA

CHILE

Puerto Coig

Rio Gallegos

Strait of Magellan

Cerro Manantiales

Punta Arenas

Porvenir

Rio Grande

Tierra del Fuego

Ushuaia

Navarino

Hoste

Bay of Nassau

Cape San Diego

Staten I. (Estados I.)

(Claimed by Argentina and Chile)

Cape Horn

South Atlantic Ocean

Saunders Island

Westpoint Island

King George Bay

Cape Dolphin

Wickham Heights

Mt. Adam

East Falkland

Stanley

New Island

Colliers

Weddell Island

Goose Green

Lafonia

West Falkland

Falkland Sound

Choiseul Sound

Berkeley Sound

Mount Low

Kidney Island

Sparrow Cove

Rabbit Cove

Charles Point

Port William

Stanley Harbour

Stanley

Sapper Hill

STATUTE MILES

© National Geographic Map

Drawn by Victor J. Kelley and Robert C. Ellis, Jr.

Shepherds in Berets Ride Rangeward to Round Up Flocks for Shearing

Falkland sheep farms range in size from 3,600 to 400,000 acres. As many as 80,000 sheep may graze one farm.

The Falkland Islands Company exports hides and about 4,000,000 pounds of wool a year. Frozen mutton has been shipped to England since the erection of a refrigeration plant in 1953. Previously, slaughtered carcasses were thrown into the sea or used for fertilizer.

All Falklanders outside Stanley live in what is known as the camp, from the Spanish word *campo*, meaning field or countryside. Many homes stand in settlements, consisting of shearing shed, cookhouse, and a store.

In summer the shepherd spends most of his time in the field or in the shearing shed. Winter finds him mending fences and repairing his home.

Few horses are bred in the islands; most are imported from Chile and Argentina. Riding gear bears Spanish names, a reminder of past centuries when gauchos visited the islands to capture wild cattle.

Dogs are a mixture of many breeds, including border collie.

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←Battle Monument Calls to Mind a Drama of World War I

On December 8, 1914, a German raiding fleet under Vice Adm. Graf von Spee steamed toward the Falklands. A British squadron, recoaling in Stanley, rushed to sea and destroyed all but one enemy ship. Victory gave the British full command of the South Atlantic.

World War II brought fresh activity. In 1940 six British cruisers anchored off Stanley. A garrison of 2,000 troops arrived in 1942 and remained for two years.

Stanley boasts the Falklands' only paved roads. Motor vehicles number around 200.

Golden gorse blankets the bluff on which the memorial stands. Government officials occupy hilltop homes.

Shearing Sheds Dominate Goose Green Settlement on Island-specked Choiseul Sound

There was no way of knowing why this particular route was chosen; certainly it was not the quickest or the easiest. At least a mile long, it led across small ravines, up eroded peat embankments, and through patches of diddle-dee. No penguin ever ventured from the path to find a better way. All merely accepted the ancestral trail, however inconvenient, and made the best of it.

For these heavy-bodied, short-legged creatures, practice never seemed to make perfect. Even though the birds had made the trip many times, every obstacle—rock, ditch, or steep incline—seemed to require much deliberation before it could be passed, just as if they had never been confronted with it before.

After an hour or more of plodding, the birds arrived at the colony. Here nests were so close together that two penguins sitting on neighboring ones could almost peck each other if they stretched their necks to full length. Each returning gentoo, showing no hesitation, headed for its own nest, often in the very midst of the aggregation. This inevitably meant running the gantlet—rushing and dodging between nesting birds while receiving angry jabs from strong beaks.

Once the wanderer reached home there followed a noisy ceremony as the arriving bird and its mate, together again after many hours, greeted each other by bowing, hissing, and trumpeting lustily (page 412). Eventually the mate, which had been incubating their two eggs, was relieved of responsibilities and made its way, usually early the following morning, over the long trail to the sea.

Idle Gentoos Turn to Thievery

In the colony were many birds waiting to spell their mates on the nest. These loafers whiled away the time stealing nesting material from under inattentive neighbors. Of course the whole performance of stealing for a completed nest was a waste of time, but you can't tell a penguin that! We saw a gentoo snatch some twigs from beneath a dozing nest sitter and bustle back to its own nest where, dropping the loot before its mate, it hissed quietly as if searching for a compliment.

Again and again the thief repeated the performance, until by chance the victim of this criminal act woke up and protested with hard blows from beak and flippers.

The gentoos accepted our presence without fear. Unless we made hurried movements in their direction, they went soberly about their affairs, which were never wanting in variation and comedy (page 411).

After several attempts to handle cameras during sudden squalls, we learned that one should not even try. He should merely cover his equipment, sit down back to the gale, and wait. In a matter of minutes the snow, sleet, and rain pass, and a brisk, very cold wind, perhaps with a spot of sun, soon dries everything in its path. Occasionally squalls followed one another with annoying frequency. No sooner were we at work after one had pelted us than we would have to fold up and endure another.

Back in Stanley we sorted our supplies, replenished them where necessary, and were away again, this time in a large vessel, the *Protector*, which we chartered for the short journey to tiny Kidney Island north of the mouth of Port William.

From the sea, green Kidney Island looked more like a tropical isle shaded by palm trees than a bit of subantarctic territory perpetually lashed by ice-cold surf. The hut we were to occupy rested snugly in the tussock grass on the island's south slope, very much alone.

A path to the hut from the little beach where we landed may have existed at one time, but it was not there now. We had to force our way up between great tussock clumps higher than our heads, with one hand holding on to strong blades to prevent slipping back on the wet mossy ground, and with the other tugging camera and camping equipment.

Very much winded, we reached the hut, erected by the Government for farmers who wished to stay on the island while cutting tussock for their livestock.

Galleon Rides Globe Atop Falklands Memorial

A statue of Victory fronts the base of the 35-foot granite monument. Bronze ship symbolizes the Royal Navy of discovery days (page 395).

© National Geographic Society

↑ Versatile Tussock Grass Feeds Cattle and Fuels Camp Stoves

Poa flabellata grows in clumps up to eight feet high. The pulpy blade has a nutty flavor; it has saved shipwrecked sailors marooned on the islands. Roots and dead vegetation burn like peat. Mrs. Pettingill saws strips from a bog on Kidney Island.

↓ Wild "Strawberries" Look and Taste Like Raspberries

Rubus geoides grows among rocks and at the base of tussock bogs where the tiny vine lies concealed among dead blades of grass. Short-stemmed berries rest on the ground. They have a tart, earthy flavor. Falkland housewives make jam from the fruit.

Kidney Island held a remarkable array of birds. As we inched over slippery, lichen-covered ledges, boulders, and loose rocks on the shore leading away from the landing beach, we met pairs of flightless steamer ducks, as heavy bodied as geese, with wings too small for flying. Drab tussock-birds and Cobb's wrens searched for tiny crustaceans in the heaps of kelp washed up by the tides. Black oyster-catchers sought mussels on rocks at the water's edge and, in the tide pools, black-crowned night herons patiently stalked small fishes.

High on a ledge, partly protected by overhanging tussock clumps, we found a nest of kelp geese. The pure-white gander stood guard while his strikingly marked spouse sat quietly on her eggs (page 412).

Penguins Duel with Bills

The tameness of these birds astonished us. The steamer ducks merely stepped out of our way; the male kelp goose, though obviously concerned by our being so near his nest, showed no urge either to attack us or to depart, but simply stood aside as we peered down at his mate. Most surprising were the tussock-birds and wrens which were underfoot, hopefully looking for any live food that our walking might stir up. Several times, when we stood still, they perched on the toes of our boots.

Countless jackass penguins, little fellows with odd black-and-white faces, hurried back and forth between the sea and the narrow trails that led through the tussock to their burrows. Always stooping forward as they walked, they gave the impression of being intent on serious business.

Now and then, however, the jackass penguins surprised us by gathering on the landing beach apparently to loiter and enjoy one another's company (page 413). While some of them napped, others took part in a variety of activities.

A favorite was bill clicking, which began with two birds standing breast to breast, hitting their bills together. Spectators soon broke into the duel, whereupon there would follow a short-lived frenzy as each bird struck wildly at the nearest available bill.

Another popular activity consisted of several birds rushing into the water, diving and cutting a wide arc seaward and back, then popping out and running back to the starting point. Always in high spirits during these social interludes, one penguin after another trumpeted, producing a long series of doleful brays like those of the jackass for which they are named.

Steep cliffs north of our hut were the home of rockhopper penguins, whose hopping gait the well-known ornithologist Robert Cushman Murphy said looked like a man running a sack race.

When we first landed on the island, we heard their grating cackles and deep-throated screeches; no birds in the Falklands are noisier on their nesting grounds than rockhoppers. But the colony was maddeningly out of reach because a jungle of high tussock stood between us and the top of the cliffs.

With belt knife and wood saw we hacked a trail through the barrier. When we finally reached the cliffs, the spectacle below us was unforgettable. Here some rockhoppers were nesting at dizzy heights on ledge shelves barely as wide as their bodies.

Others passed up and down the steep faces of the cliffs with the surefootedness of mountaineers. Occasionally a bird slipped, but never very far, for its sharp, curved claws and beak soon hooked into the rough surface.

Rockhoppers Attack Humans

The rockhoppers were as quarrelsome as they were noisy. Watching them, we sometimes imagined they bore a perpetual grudge against society. Even as several basked together in the sun on the brow of a cliff, a squabble almost invariably broke out. For no apparent reason a bird jabbed at its neighbor, starting a chain reaction that led to jabbing on the part of everyone.

Our approach to any nesting pair was usually met with defiance and not infrequently a rush at our legs. The more belligerent individuals went so far as to bite and hold on with their beaks while delivering sharp blows with their flippers. If they managed to grab above our boots, their pinch was, to describe it mildly, impressive (page 407).

Night transformed Kidney Island into one of the weirdest spots imaginable. Just as darkness descended, in from the sea came hosts of gray-backed and diving petrels, sooty shearwaters, and shoemakers to swirl over the island, then dive into burrows below the tussock, where their mates awaited them.

We were aware that these sea birds, all tube-nosed swimmers, nested on the island and had the peculiar trait of coming to land

Festive Falklanders Watch Horse Races and Play Games at a Sports Carnival

At Christmastime, ranch people head toward Stanley by plane, boat, and horseback for the annual two-day gymkhana. Business suspends; the whole town turns out.

On opening day local horses compete against a few imported racers. The major event, the Governor's Cup, is a small-scale version of the Irish Sweepstakes; winning ticketholders split a lottery.

Men, women, and children frolic about the field in competitive games.

Prizewinners receive their awards at a gala ball climaxing the festivities. Dancing—extremely popular in the islands—continues until 2 a.m. Participants saddle horses in the gray morning light and jog back to their farms. Holiday is over for another year.

Here a dappled gray leads by a length at the finish line on the grass track. Rock-strewn Sapper Hill rises behind the paddocks. Though it is summer, some spectators wear topcoats against chill winds.

Page 400, lower: Women engage in the potato race.

↓ Mixed teams vie in the wheelbarrow race.

© National Geographic Society

only at night, but we did not expect to see so many. Nor were we prepared for the muffled screams, whimpers, and groans that came from underground when rejoined pairs greeted each other.

As if the melodramatic sounds from these birds were not enough, out from their daytime hideaways in the tussock came short-eared owls to give their eerie lisping cries and whines. During these nights, while surf boomed in the distance, the wind swished across the island, and tussock blades scratched the metal walls of our hut, we marveled that Nature could produce, in one place and at one time, such a variety of hair-raising sounds.

Whalers Left Meat on the Hoof

Back in Stanley once again early in December, we decided to interrupt film work and cruise on the *Fitzroy* around the camp, a journey of about 11 days during which the little ship circled the islands and called at the sheep farms to deliver supplies and mail and pick up wool. While we awaited the sailing date, we steeped ourselves in Falklands lore.

We learned that no primitive peoples ever inhabited the islands. John Davis first sighted these bits of land from the vessel *Desire* in 1592, and European seamen had hazy knowledge of their existence for the ensuing century and a half. Nobody came to live in the bleak archipelago until 1764, when the French established a settlement at Port Louis on East Falkland. One year later the British, presumably unaware of the presence of the French, put a garrison at Port Egmont on Saunders Island off West Falkland.

Spain shattered the calm with a claim to all South Atlantic lands. Her bluster forced France out permanently in 1767, but the British left Port Egmont only long enough to convince themselves the Spaniards were bluffing. Threatening war, they came back, and Spain left them unmolested. Despite all the trouble they took, both Britain and Spain soon abandoned their settlements, leaving the islands a virtual no man's land.

Many of the smaller islands, especially those off West Falkland, became the haunts of sealers and whalers from Great Britain, New England, and Nova Scotia. Here they deposited sheep and goats, even left men to plant gardens, as an assurance of food supply while they hunted near by and in the Antarctic. With no government to oppose them, they considered the resources of the islands rightfully theirs—even untold thousands of penguins which they boiled down to augment their supply of whale and seal oil.

Argentina claimed the Falklands in 1828, and a year later appointed a governor, who soon revived the settlement at Port Louis. But foreign whalers and sealers continued to exploit the islands as they chose. The Argentine governor arrested some American sealers for their depredations in 1831, whereupon an aroused United States consul ordered the warship *Lexington* to the Falklands. Besides destroying the fort, the American ship's captain took some prisoners, who were eventually freed in Montevideo.

By 1832 Great Britain reasserted her claim to the Falklands and in the following year forced the remaining Argentine occupants of Port Louis to leave. From that date the Falklands became established as a British colony, though to this day Argentina still claims them.

We soon became impressed with the important role of the Falkland Islands Company in the islands' development. From its organization in 1851, for the main purposes of killing wild cattle (descendants of animals introduced by the early settlers) for food and hides, increasing and improving the sheep stock, establishing a general store, and providing regular postal service between the islands and the outside world, it had become the colony's chief farmer, owning more than half the land area.

In addition to owning and operating the *Fitzroy*, the FIC functions today as banker, storekeeper, and often lawyer, adviser, and guide for the farmers.

Mysterious Rivers of Stone

We sailed from Stanley on the *Fitzroy* at dawn one December morning. As we joined our fellow passengers for breakfast, we passed within sight of Wickham Heights, a range of rugged hills on East Falkland reaching above 2,000 feet elevation.

Later, from the deck, we watched the mainland flatten out and at times almost disappear between sea and sky. This was Lafonia, the great southern part of East Falkland, level as a Kansas prairie, with scarcely a hill or rock to break its monotony. The one farm home we saw here, as the *Fitzroy* lay offshore while mail was delivered, stood alone without shelter from the relentless winds.

By late afternoon the scenery changed as

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***Great Britain*, Onetime Queen of Ocean Liners, Lies Grounded in Sparrow Cove**

This 322-foot steamer, launched at Bristol in 1843, was a pioneer iron ocean-going ship. For decades she carried emigrants to Australia. In 1882 she was converted to a three-masted sailing ship; worn-out engines were removed and the hull was sheathed in wood. Four years later she limped into Stanley after being partly dismasted in a gale off Cape Horn. For 50 years the vessel remained moored in the inner harbor as a wool and coal storehouse. The *Great Britain* was towed to Sparrow Cove in 1936 and sank in six feet of water. Today rock shags with big webbed feet stroll the deck where Queen Victoria once walked.

we approached West Falkland. Sheer high cliffs marked its southern coast, while giant rocks, often covered with enormous numbers of nesting king shags, jutted out of the sea offshore. On the west coast many cliffs had toppled and slid into the water; above them rose badlands comprised of strange rock formations. We saw many white beaches and sailed past numerous green tussock islands. The hills averaged higher than on East Falkland, and one, Mount Adam, reached 2,315 feet, the archipelago's highest point.

All the farms we visited were nestled on the shores of fjordlike inlets or small bays, with hills rising steeply on all sides. Usually conspicuous on these slopes were "rivers" of stone—an interesting geological phenomenon of the Falklands with as many explanations as there are geologists who have advanced them. Whatever their origin, they consist of boulders and sharp rocks which appear at a distance as gray streams pouring down the hills into the sea.

The farms were startlingly beautiful. Houses, white with red roofs, rested on the lower slopes or on benches above the sea. Gorse, at the height of its yellow brilliance, outlined every garden and paddock. At some farms the shrub had escaped to form blotches of color on the gray-green hillsides.

Only a few establishments had jetties large enough to accommodate the *Fitzroy*, so she usually had to anchor offshore. Her crew lowered a motor launch and two barges from the deck and began at once to load the barges with supplies. Since the coming of the ship had been announced in advance by wireless, men on shore were already rolling bales of export wool onto the jetties.

At several farms we had time to go ashore,

though we never knew when the ship would be ready to depart. We always kept an ear open for the tooted warning to come aboard.

We were always welcomed warmly and given breakfast, lunch, tea, or dinner. Between these social occasions we inspected the buildings, wandered through gardens and sheep paddocks, and, if the weather was mild, climbed some of the near-by hills.

Some of the holdings were large enough to warrant the name of settlement, with a population, counting shepherd families and laborers, of more than 40 people; but most included only the owner or manager and his family and one or two shepherd families. At each farm, close to the jetty, stood a wool shed, a low building with shearing pens, tables for sorting wool, wool bins, and huge presses.

At two of the FIC farms we were somewhat awed by the managers' new manor houses, prefabricated in Sweden and shipped in pieces to these locations, where carpenters had assembled them. Both were unexpectedly large. Wide halls led to many rooms, luxuriously fitted even to parquet floors, running water in bedrooms, and central heating.

Albatross Egg Fills a Platter

After enjoying many meals, we soon believed what we had been told in Stanley—that the best cooks in the world live on West Falkland. In addition to mutton, the main food in all the islands, we had our first albatross and penguin eggs, the former large enough when fried to fill a dinner plate; Falkland pie, a combination of eggs and bacon that is a meal in itself; spring lamb, fit only for the gods and unlike anything sold as lamb in American markets; and gosling pie, made from the tender young of the upland goose.

Conversation at meals or afterwards began with the price of wool and the progress of

shearing, but it soon drifted into discussions of plays seen in London or of the state of world affairs. Most of the islanders, we found, visit England more often than most Americans go to New York. A few of the owners and their families return to the motherland as often as every other year, while the FIC's farm managers and other employees, together with their families, take a six-month holiday in England every three years.

In every owner's or manager's home there was a two-way radio-telephone set supplied by the Government. Each day, at an appointed time, someone, generally the wife of an owner or manager, talked to Stanley. Almost invariably she reported on the weather (always important news in the Falklands!); sometimes she sent or received telegrams for the farm people, talked with the doctor if there was a medical problem, or called the harbor master if a plane was needed.

In the event of an emergency requiring a doctor or a trip to the hospital in Stanley, the plane would come if weather permitted. When the plane was needed only for a business or social visit, a reservation would be made and one waited his turn, which might take a few days or weeks.

Nearly every home has its radio, on which it receives Stanley news and various programs by shortwave from London or the United States. Many farms have electric plants providing power for radios as well as for illumination and pumps. Those without this machinery rely on batteries revived daily by wind chargers, always a dependable means of power in the Falklands.

Education on West Falkland and elsewhere in the camp is supplied by traveling teachers, who journey by horse, boat, or plane from

← Lambs Rush from the Pen After a Night's Captivity

Twenty-four hours earlier shepherds rounded up the entire flock and drove it into the paddock. Too young for shearing, these lambs are freed in early morning. Grown sheep, divested of their coats, will join them in the fields later.

↓One sheep yields about 11 pounds of wool. An experienced shepherd can remove the fleece with hand clippers in 10 minutes. Jacob Goss demonstrates his handiwork.

farm to farm, spending two weeks here or a month there. Actually a teacher has time in his brief visits to accomplish little more than find out what work the youngsters have covered since he was last there and to outline material for future study. The real burden of teaching falls on the mothers. Some children live with friends or relatives in Stanley, where they attend school through the eighth grade. Parents with the means send their children to England for higher education.

Though such modern means of communication as planes and radios have made the farms much less isolated, the people are nonetheless alone and left to their own devices most of the time. Yet on our 11-day trip around the camp we never heard the words "lonely" or "bored" uttered by anyone.

By the time we arrived back in Stanley, just before Christmas, spring had turned to summer. Now there were days when the sun shone steadily, intensifying the radiance of the yellow gorse, the red roofs, and the blue-green of Stanley Harbour. Flower gardens were at their best, for the lupines were in full bloom, as were pansies and primroses.

Races for Horses and Humans

People began arriving in Stanley by boat, plane, and on horseback from all over East Falkland to attend or participate in the races under the auspices of the Stanley Sports Association, an annual event on the two days after Christmas (page 400).

All the races, for horses as well as humans, took place in the paddocks on the side of Sapper Hill. Shops and businesses were closed while everyone went to the races. These two days were packed with fun for all.

The most rewarding part of our Falklands adventure was the five weeks spent on New Island, off the western side of West Falkland. Here we were the guests of the owner, Jack Davis, and his wife, Agnes (page 408).

Taking the first plane to leave Stanley after the holidays, we flew first over the interior of East Falkland, a forbidding monotony of rocks, white grass, and diddle-dee. We could understand why the pilot did not relish the idea of flying his single-motored craft over this country; all of us were happier when we were above Falkland Sound and later the greener camp of West Falkland.

Soon we were settling toward New Island, shaped like a crescent but with an amazingly irregular coastline, high hills, precipitous slopes, and innumerable valleys. In a few moments we were coming down gently onto a small bay and looking up at the Davis home snuggled against the hillside.

New Island seemed like a world on edge, for there was precious little level ground. In some places the land was narrow and could be measured in yards; in others it was more than a mile wide.

Surf Shrouds Cliffs in Spray

On the island's eastern side the hills, some reaching above 700 feet, dipped gradually toward the sea, but on the western side they plunged abruptly in tremendous cliffs, as if their lower slopes had been sliced off and removed (page 388). Thunderous surf from the open Atlantic climbed part way up the frowning cliff faces, sometimes sending spray over their brows.

New Island provided much to complement our film story. Up to this time we had worked mostly on the activities of penguins, but here, in addition to the same three species of penguin, were thousands of other birds —black-browed albatrosses, dolphin and kelp gulls, skuas, king shags, Fuegian oyster-catchers, several kinds of geese and ducks—together with herds of sea lions and fur seals and a backdrop of spectacular scenery.

Though we roamed over much of New Island on horseback, seeking attractive settings for photography, the best spot was within walking distance of the Davis home. There sheer cliffs dropped into the Atlantic, interrupted by gullies that led down to the surf. On the slopes, just above the cliffs and gullies, stood the biggest nesting assemblage of birds we have ever seen close at hand.

Rocks Scarred by Penguin Claws

The majority of the nesting birds consisted of about 50,000 pairs of rockhopper penguins. When we first saw the colony in early January, each nest contained at least one chick, coal black with white belly, so roly-poly in shape that the strongest wind could never blow it over. Later, as the days passed, the chicks tended to roam from their nests and band together in groups, sharing one another's company and body warmth. Only when hungry did they return to their nests or parents.

The parent rockhoppers porpoised in from the sea in great batches, often of 100 or more. As they neared their special landing place at

(Continued on page 415)

Rockhopper Penguins Wear Bushy Crew Cuts

The **Rockhopper**, or **Jumping-jack**, most numerous of all Falkland penguins, bounds forward with feet together like a kangaroo. He is not as awkward as he seems; moving on prehensile toes, he picks his way up a difficult cliff with the surefootedness of a mountaineer. Returning to the ocean, he uses the same trail. Often he leaps feet foremost from ledge to sea.

Male and female *Eudyptes cristatus* are almost identical. Yellow tufts sticking out beneath the glossy black plumes give the bird an impish look.

→ At least one parent always attends the chick. Often one broods while the other seeks food at sea.

↓ When a human approaches the nest, the parents cackle and grunt in warning. If he comes too close, the birds attack his legs. Yellow feathers standing out at right angles show these birds are angry. Crimson eyes, usually half-closed in daylight, open wide when danger threatens; pupils contract to pin-point size.

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Refusing to Flee, a Disturbed Albatross Clings to Her Nest with Webbed Feet

Mrs. John Davis spreads the 7-foot wings of a **Mollymauk**, or **Black-browed Albatross**, (*Diomedea melanophris*). Gloves protect against the sharp, hooked bill. Rockhoppers swarm on the cliffs of New Island.

↑ **Mollymauk Glides with Effortless Grace**

Fierce winds of the Falklands prove ideal for the black-browed albatross. The big bird can barely take off or land in still air, but once aloft it can soar indefinitely without flapping the wings.

Webbed feet, functioning as brakes in landing, resist onrushing air and slow the forward motion. With wings held high, the mollymauk strikes the water obliquely and skates forward several feet.

Parent and Chick Occupy a Mud Nest →

A single egg is laid in October. The fledgling albatross, at first closely brooded, is later left unguarded. Skuas and other predators never molest it, apparently finding the flesh unpalatable.

Parents abandon the young and head to sea in March or early April.

Sexes are indistinguishable. Dark feathers streaking the eyes of adults give a dour, frowning expression. Nestlings have smoky-white down and black bills.

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↑ *Fitzroy* Pays a Call at Westpoint Island

This 855-ton steamer, the Falklands' regular link with the world, makes the 1,160-mile voyage from Stanley to Montevideo, Uruguay, about 12 times a year. Between trips, the vessel steams around the islands, delivering supplies and mail and picking up wool.

Fitzroy here anchors in Westpoint Island's fjordlike harbor. Motorboat and barges lowered from the deck are being loaded for the trip ashore.

Westpoint's owner lives in the rambling, red-roofed house at right. The other dwellings are used by shepherds. Hedges protect gardens from the relentless wind.

This Dandy Catches Mollusks for a Living

Fuegian Oyster-catchers catch no oysters; in the Falklands they feed on mussels exposed at low tide. A single clip of the chisel-like beak opens a small shell. Coral-red bill and bright yellow eyes contrast with the black-and-white plumage. Falklanders call *Haematopus leucopodus* the Black and White Curlew.

↓ The penguin is as inquisitive as he is fearless. He moves in close to see an object, apparently because he is myopic. These young **Gentoos** (*Pygoscelis papua*) crowded about the author and his camera.

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↑ "I'm Home!" Trumpets a Gentoo

Vibrant calls ring out across the Falkland hills in mating season. If this bird finds his mate at home, they will engage in a trumpeting duet.

↑ Jackass Penguins Promenade on the Sands of Kidney Island

An odd trumpet call, like doleful braying, earns the nickname **Jackass Penguin** for *Spheniscus magellanicus.* Black-and-white stripes about head and breast give the bird a harlequin look. It waddles with a stoop.

On a visit to Kidney Island, the author watched this group preen and play on the beach. At intervals they chased one another in and out of the surf and engaged in strenuous bill-clicking duels.

→**Macaroni Penguin** (*Eudyptes chrysolophus*) closely resembles the rockhopper (page 407). It stands a bit larger, and head plumes are more orange than yellow.

Macaronis nest on South Georgia, the South Shetlands, and the South Orkneys. Occasionally a solitary bird strays northward to the Falklands and mixes with a rockhopper colony. Snubbed, he soon departs.

←No other geese show as great a difference between sexes as the **Kelp** (*Chloëphaga hybrida*). The gander's plumage is snowy white; the female is spotted and barred. Gray-white goslings blend in with the rocks. Here a pair crouches at mother's tail.

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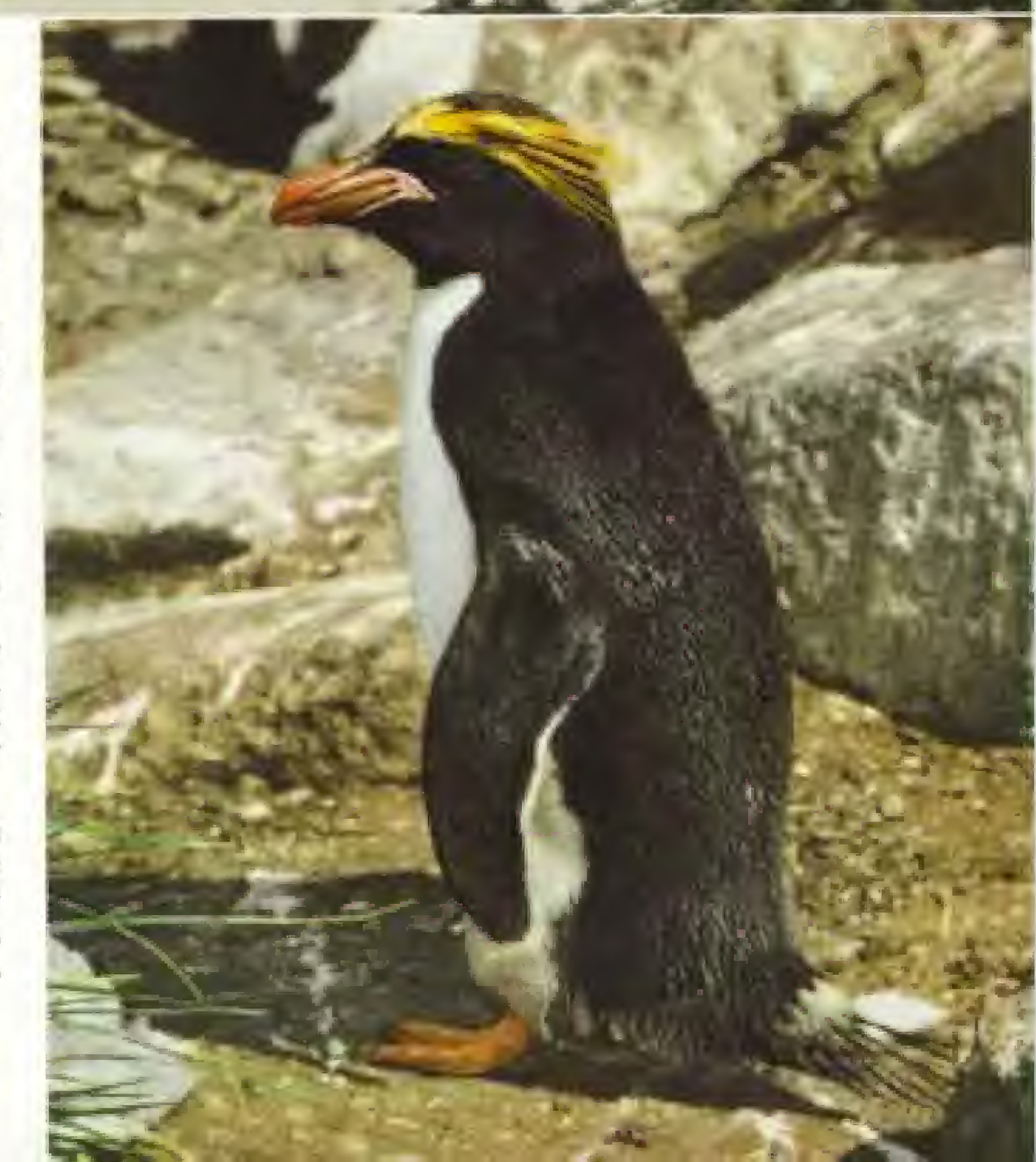

← "I Look Like This?" Young Gentoo Wonders

During four months in the Falklands, photographer Pettingill filmed the entire nesting cycle of penguins.

This adolescent gentoo, unused to water, saw his reflection for the first time. Fascinated by the image, he contemplated it at length, then abruptly waded into the puddle.

↓ King Shag Nests in a Penguin Colony

Shags, like penguins, pilfer one another's nesting materials. Should this bird leave the nest unguarded, neighbors might whisk away the tussock grass and leave eggs on bare mud.

A handsome cormorant of the Falklands, the **King Shag** is sometimes called Blue-eyed Shag because of the blue skin around the eyes. Upswept crest and white bar on wing disappear from *Phalacrocorax albiventer* after the breeding season. Fleshy orange cockle atop the bill is a permanent feature.

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the base of the cliffs, they flung their tough little bodies from the churning surf, caught a foothold, and hopped quickly up the wet, slanting ledges to a safe resting place beyond the waves.

In order to reach their lofty colony, they had to funnel themselves up through the narrow, rocky gullies, a laborious procedure that required much scrambling. As we watched them working their way up, we were astonished to find that the rocks on which they climbed had deep, vertical scars, formed by their sharp claws. Since the rocks were of a hard, sedimentary type, such prominent marks could have been made on them only by the yearly passage of millions of penguins over many centuries.

Skuas Pounce on Baby Birds

Nesting with the rockhoppers were a thousand or more pairs of king shags and several hundred pairs of black-browed albatrosses (pages 409 and opposite). Despite the proximity of the three widely different kinds of birds, each respected the others' rights and let them strictly alone.

In fact the albatrosses, sitting on their high mud nests among the penguins and shags, seemed totally aloof from their smaller neighbors. By the time of our visit, both the shags and albatrosses had young; unlike the rockhopper chicks, they stayed in their nests until almost fully grown.

Adult rockhoppers, king shags, and albatrosses have no enemies when nesting and therefore show no instinct to leave their nests when approached (page 408). But young rockhoppers and shags are the prey of skuas, which always lurk about colonies. At this one there was always a skua in sight, ready to pounce on and carry away any young rockhopper that strayed too far from the adults, or any young shag left unguarded.

Bird Nearly Unseats Author

At their own nests, where they bring baby penguins and shags to their hungry young, skuas are notably belligerent when approached, as if they were determined not to let indifference to strangers result in the loss of their offspring (page 389).

When we walked up to a skua nest, we made it a custom to carry a stick (an object not easy to come by on New Island), for we knew that the old birds would take to the air and attempt to strike us with wings and beaks. The stick served to discourage their blows but not their angry protests.

Skuas, we found, attack horses and dogs with the same courage. Once as we rode horseback, we saw a sheep dog pass too close to a skua nest. In an instant the old birds went after him, but the dog, wise in the ways of skuas, dashed toward the horse on which I was riding and took refuge below. The skua consequently centered its attack on me—on horseback without a stick! I managed to stay in the saddle.

Our days on New Island were busy. When the weather was stormy, which was often, I collected and prepared bird specimens or made observations on the many birds near the Davis home. Occasionally we took time off from camera work to explore the fastnesses of the island, to see the ruins of an old whaling station run by a company that moved long ago to South Georgia, or to climb over the rusty superstructure of a half-sunken ship in search of starfish and mollusks. Once we sailed with Jack Davis in his schooner around the Colliers—weirdly shaped rock formations, suggesting the prows of two ships, rising high above the waves.

All too soon, it seemed, the time came to bid the Davises goodbye and fly back to Stanley. As we left them, I remarked, "If your island were off the coast of the United States, it would be a famous national park, visited by thousands every year."

"Heaven forbid!" Agnes replied. "I'm glad it's where it is."

Penguin Teen-agers Peck Tripod

February was devoted to filming the last stages in the nesting cycle of penguins. First we went back to Charles Point, where the young gentoos had reached the "teen-age" stage. Almost full-grown, but with down still clinging to parts of their bodies, they were more comical than ever.

Their curiosity about us and everything we did seemed insatiable. As soon as we appeared, they circled us a hundred strong and, without uttering a sound, became an attentive audience. Gaining confidence, they worked their way up to us, nibbled at the tripod, poked at the camera box.

When I put a shaving mirror on the ground in front of them, they forgot all about us mere humans and began pushing and shoving one another to get close to it. One youngster after another, on seeing his reflection, tried

The Author Needed a Workshop; Falklanders Obliged with "Pettingill's Parlour"

to grasp it in his beak, only to lose the fascinating object of his quest when he knocked over the mirror.

Next we returned to Kidney Island, where the young rockhoppers had almost attained the size of their parents. Far more interesting than the youngsters to watch and film were the old birds which, their home duties about over, had begun to molt. Big patches of old feathers clung to the tips of newly formed feathers, giving them a moth-eaten, bedraggled look.

Their molting, we discovered, had in no way lessened their quarrelsomeness and noisiness; if anything, it seemed to have aggravated their mean dispositions. Fights continually broke out, with feathers literally flying. Each time one individual grabbed at another, he got a mouthful of feathers, and when he struck another with flippers, he knocked out more feathers.

Sometimes free-for-alls developed, a dozen or more penguins pinching and striking one another wildly and falling into feather-filled crevices, with the result that we could scarcely see the struggle because of the feathers in the air. Sometimes it seemed as if a pillow had suddenly exploded.

We could have kept on photographing penguins indefinitely and always been sure of catching something not yet recorded on film, for, despite the fact that they repeat certain actions countless times, they never perform in quite the same way. In only one respect are they consistent—they are unfailingly amusing.

In our final days in Stanley our hardest task was saying goodbye to the many people who had been so kind to us and so sincerely interested in the job we had come to do. Time and time again we found ourselves saying, "We'll be back someday." It was a simple statement, but abundant evidence of how we felt about the Falklands.

Expedition to the Land of the Tiwi

On Australia's Remote Melville Island, Civilization Is Overtaking Aborigines Living 50,000 Years in the Past

By Charles P. Mountford

Leader, National Geographic Society Melville Island Expedition

OUR expedition to Melville Island could hardly have had a less auspicious beginning.

On the flight across Australia, from Adelaide to Darwin, the outer edge of a cyclone had tossed and buffeted our plane. Now, 24 hours later, we stood disconsolate on the muddy shore at Darwin. The five of us were waiting for a dinghy to take us aboard a decrepit steel landing barge ludicrously called the *Triumph*. We had no choice of transport, this being the only craft going to Melville Island for months.

It was a gloomy departure, with the rain pouring steadily and the night inky black except when lightning revealed the desolate scene around us. We all felt apprehensive about the journey ahead.

Stone Age Survivals

In one sense, in that April of 1954, we were traveling backward in time as we moved forward in space. Our destination was the largest of Australia's coastal islands, save for Tasmania (map, page 425). There, in the little-known land of the Tiwi, we would see man living much as he did 50,000 years ago.

The Tiwi, one of the few archaic peoples left on earth, have no agriculture, no permanent homes, no pottery, and no domestic animals except the dog. Only yesterday they had no tools except the crudest of stone axes, specimens of which can be found discarded all over the island. Their weapons are spears and sticks. It is a marvel that their culture has survived with so little change.

Through the sponsorship of the National Geographic Society, our group of American and Australian scientists was to make a five-month study of these Stone Age hunters before their customs and unparalleled ceremonies are lost forever.

But it was not the thought of primitive men that worried us as we boarded the *Triumph* and sat shelterless on the cargo, our spirits dismal and our bodies damp. Rather it was the hazardous 40 miles between us and Melville, the swiftly running tideways and the reefs and shoals of Clarence Strait. Before installation of a series of buoys, no ocean-going vessel would have attempted to navigate these broken waters at night.

Hours later at sea, just as we reached the worst part of the strait, a heavy tropical storm hit us. High seas battered our craft unmercifully, lifting her flat-bottomed, cumbrous hull out of the water on the crest of one wave and dropping her violently into the trough of the next. Sheets of spray flew over us on a howling wind.

Then the rudder jammed, and in an instant the craft was at the mercy of the raging waters. We spent anxious moments until the *Triumph* was again under control. Had we known that the shock of heavy seas had fractured her rusty bottom and that the flotation chambers were filling with water, we should have been more than anxious. Only when a heavy list developed and the skipper beached the *Triumph* at Garden Point, on Melville Island's west coast, did we learn what had happened.

It is doubtful if any of the simple and frail bark canoes of the Melville islanders, their only water transport before the introduction of the dugout canoe, could have withstood the turbulence of that passage. This fact helps to account for the unusual isolation of the island and its long freedom from the influences of civilization.

An Ill-fated Outpost

While the *Triumph*'s crew laboriously cut holes in the steel deck so that water could be pumped from the flotation chambers, I visited near-by Fort Dundas.

With the memory of the barge journey strong in mind, the ceaseless rain, the oppressive humidity, and the dank vegetation made it easy to imagine the sufferings of those unfortunate Englishmen who once manned this lonely outpost. In the 1820's Britain sent Capt. J. J. G. Bremer of the Royal Navy to establish a settlement on Melville. Commanding a contingent of soldiers and a gang of convicts, he established Fort Dundas on

Associate Justice William O. Douglas

An Aboriginal Hunter on Australia's Melville Island Catches a Young Wallaby

Wurarbuti, a Tiwi tribesman, is skilled with the spear; using a throwing stick, he brings down geese on the wing. On this hunt, however, he stalked his prey, running when it ran and stopping when it stopped. Finally, within 25 feet of the animal, he ran with a burst of speed, caught it by the tail, and killed it with a knife. By custom, he keeps the forequarters but shares the rest.

Scientist Measures → Stone Age Man

The National Geographic Society Melville Island Expedition went to the little-known land of the Tiwi in 1954 to study one of the world's most archaic cultures.

The Tiwi plant no crops, build no permanent houses, make no pottery, and collect few possessions. Their basic tool is the ax—steel today, but stone only a few generations back. Their natural way of life as hunters and food gatherers is largely that of 50,000 years ago.

Age-old customs are practiced side by side with ways recently adopted from white men.

Dr. Carleton S. Coon (shown), anthropologist of the University of Pennsylvania, spent 10 days with the expedition gathering physical data on the Tiwi (page 433).

Charles P. Mountford

the northwest shore of Apsley Strait, which divides Melville and Bathurst Islands.

Supply ships failed to arrive, and the settlers—assailed by hunger, tropical diseases, and occasional spears of the Tiwi—abandoned the fort after less than five years.

Yet so vivid an impression did that garrison make on the minds of the aborigines that 125 years later they were able to tell us about men who wore red clothes and large shiny buttons and who made loud noises (cannon). They knew that men in dark clothes (the convicts) did all the work. It seems incredible that the detailed knowledge of such a brief settlement could have persisted for so long in the tribal memory.

Centuries of Isolation

Few white men have visited Melville since, although the hunter Joe Cooper lived there for a time 40 to 50 years ago, shooting herds of water buffalo whose forebears had been imported from Timor by Bremer's soldiers. The Australian Air Force maintained a landing strip at Snake Bay during World War II.

Back on the *Triumph* aborigines labored incessantly at the hand pumps as we limped along the coast for another 50 miles. Finally the rusty old barge made port at Snake Bay. Her next journey was to be her last. While she was being towed back to Darwin after her engines had failed, her rotten hull fell apart and she sank.

At Snake Bay we found a warm welcome from the native affairs officer and his family. The aborigines, too, received us in friendly fashion, for they looked on our guide and mentor, Bill Harney (Bilarney), who had spent many years among them, as a "proper good-fellow" (page 423).

With native help, we were soon camped on Banjo Beach about a mile north of the Government station. Bill, who had been our guide on the National Geographic expedition to Arnhem Land in 1948,* transformed some empty oil drums and a pile of corrugated iron into a dining shack and cookhouse. A lily-covered billabong, or swamp, filled with white-trunked paperbark trees made a backdrop; the ocean lapped constantly at our front door.

A dozen of the aborigines with their families camped on the edge of the billabong to work as hunters, food gatherers, water carriers, and general handymen. Following custom, they threw together the rudest of brush shelters for protection from sun and rain; at night they slept in the open between campfires.

* See, in the National Geographic Magazine: "Exploring Stone Age Arnhem Land," by Charles P. Mountford, December, 1949; and "Cruise to Stone Age Arnhem Land," by Howell Walker, September, 1949.

The Tiwi men of Melville Island, a fine lot physically, are among the tallest of the Australian aborigines; an occasional man reaches nearly 6 feet. They are well-muscled and dignified in carriage. Their hair is curlier and their skin blacker than is true of the mainlanders.

Like Australia's other aborigines, however, they delight in decorating their arms and chests with welted scars, usually in chevrons or straight lines (page 419).

Scientist Takes to the Bush

We found the Tiwi a kindly, courteous people with a fine sense of humor. They proved able and willing helpers, especially when they understood the object of our visit and learned something of our working methods. Communication was not overly difficult, since many of them spoke a kind of pidgin English.

The expedition saw comparatively little of two of its scientists. Brian Daily, our geologist from the University of Adelaide, took off for the bush with a guide, an aborigine ludicrously named Charley Four High, and lived off the land for weeks at a time. His tall figure was easy to spot when he occasionally returned to headquarters, for he soon grew a magnificent red beard.

Daily's pockets—especially those of his shirt—were his filing case, overnight bag, and storage compartment. They bulged constantly with rock specimens and fossils, notes, toothbrush, and miscellany. When he left the island, his shirt and pants were held together more by safety pins than by thread—witness to the hundreds of miles he had covered on foot and the weight of specimens he carried.

This member of our expedition was work-

Eager Pupils Study the Abacus in Melville Island's First School

Until this school opened on Snake Bay in 1954, children on Melville had little formal education. Sandy McKay (right) teaches the three R's to youngsters by day, to adults by night. Avid learners, the children finished three grades' work the first year.

Milikapiti (spelled out on the blackboard) is the hill on which the Government station stands.

A. J. Lambert

ing in an almost virgin field. Although a geologist had sailed around the island 50 years previously, he had been afraid to venture inland for fear of "blood-thirsty savages."

Daily's purpose was to study the geological history of both Melville and Bathurst Islands. He found beautifully preserved fossils of ammonites, crabs, lobsters, bivalves, and sharks' teeth dating from the Cretaceous period of 70,000,000 years and more ago. His collection of these and other fossils was the largest to reach the University of Adelaide for many years.

The location of our camp was admirably suited for our ornithologist, David Parsons of Yale University. Within a radius of a few miles he was able to collect in all the physical environments of the island: the seacoast, mangrove swamps, eucalyptus forest, monsoon jungles, and the fresh-water lagoons.

The day was never long enough for Parsons. Always before we had assembled for breakfast he would be far afield, sitting quietly in the jungle, squeaking to attract small birds; creeping through the undergrowth in search of rare species; or plowing through muddy swamps intent on some dweller of the mangroves.

The aborigines, who value a bird in proportion to its size, were completely puzzled when Parsons spent hours stalking a bird the size of his thumb, while ignoring the larger fork-tailed kite, a common species.

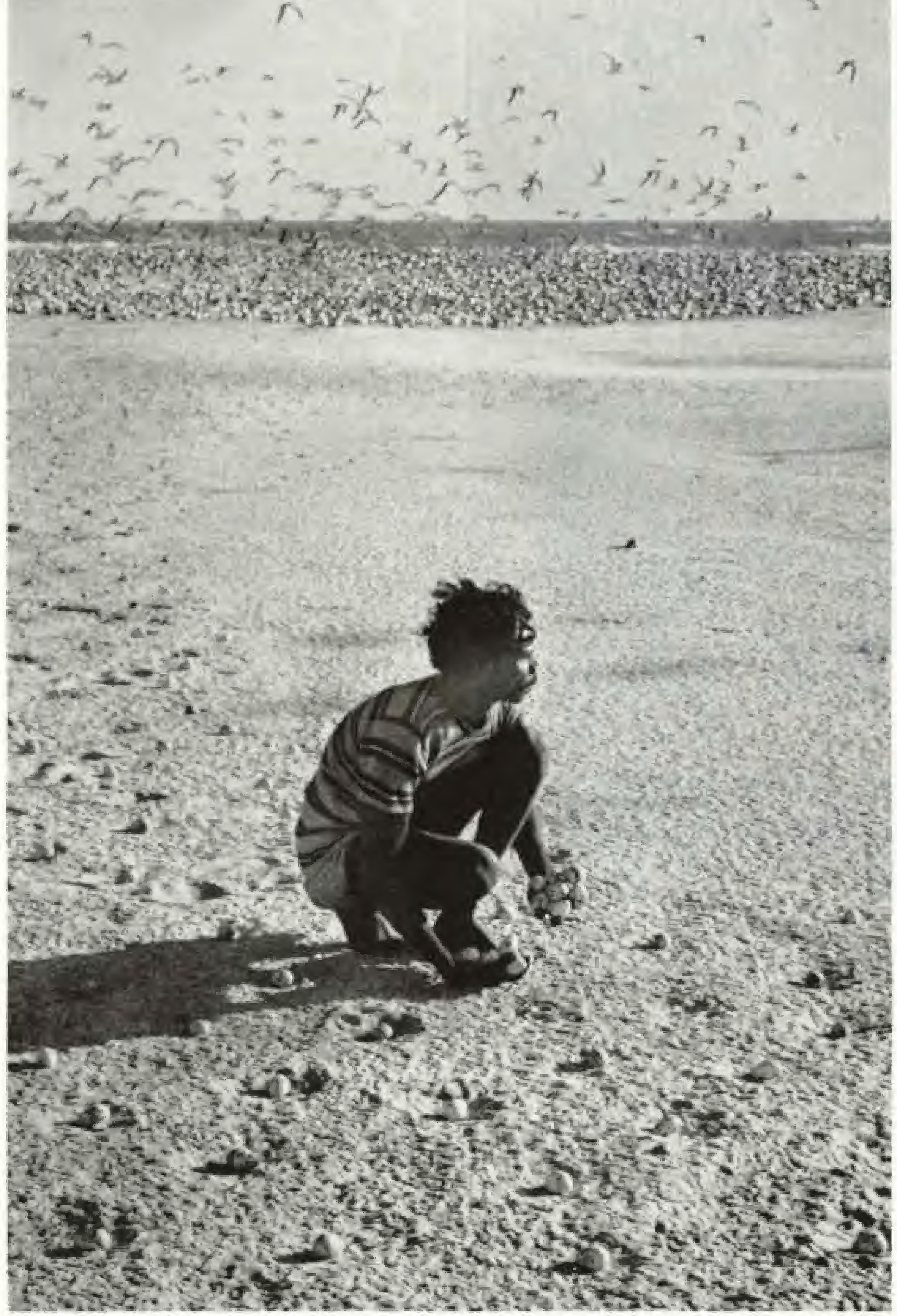
Bird Nest Big as a House

In the glow of our pressure lights at night, the rest of us might be writing up our notes or engaging in a rousing game of Scrabble. But Parsons was always busy in his tent until all hours, skinning and preparing his bird collection. He left after six weeks with 279 specimens and an estimated 75 different species. How many of these represent rare species will not be known until further study.

Perhaps the most fascinating bird collected on Melville was the scrub fowl, *Megapodius reinwardt*. This brown bird is the size of a large rooster, with tremendous feet for scratching. It is a cautious creature, living in very dense scrub. Its nest is an immense mound of dirt, leaves, sticks, and debris scratched into a pile sometimes 50 feet in circumference and 15 feet high. The eggs are laid about three feet deep in the rotting vegetation, which provides the heat necessary to incubate them.

Without Bill Harney our work would have been immeasurably harder. This remarkable man, now 60, has spent a lifetime roaming the thousands of miles of coasts and desert in northern Australia. He has "gone bush" for long periods, dressing and living much like the aborigines he knows so well. His books and poems about the aborigines are immensely popular in Australia. We could not have had a better guide or translator or companion.

Jane Goodale, an ethnologist from the Uni-



Arnold Pilling

Terns' Eggs Litter a Beach Like Gravel. One Plunderer Sends a Thousand Birds A-wing

Periodically the Tiwi get permission to "go walkabout" and resume the hunter's life. They devote most of their time in the bush to the never-ending search for food. These sea birds nest in a little-frequented spot.

versity of Pennsylvania, was interested in the everyday pursuits of the Tiwi, and especially in the status of their women. She stayed on Melville for three months after the rest of the expedition left, and her reports on the daily life of the Tiwi—particularly the womenfolk—will stand as a milestone for years to come.

For my part, I had come to study the art and mythology and ceremonials of this isolated tribe. Let me sketch briefly the background in which we viewed these things.

Melville and Bathurst Islands, which have been aptly described as two rugged paving stones fitted together on the map, are aboriginal reservations owned by the Tiwi. Until fairly recent years the tribesmen spent all their time in search of food, hunting with ax, spear, and throwing stick and gathering the produce of wild plants. They share with the aborigines of northern Australia the simplest way of life to be found anywhere in the world.

Today a mission directs the lives of some 700 Tiwi on Bathurst, and ecclesiastical pressure has banished some of the most colorful of their customs.

On Melville the Australian Government keeps 180-odd Tiwi camped around the Government station, where they are fed at a canteen and provided with loincloths as well as Western clothing.

Families Go Primitive

The aborigines are required to work regular hours for food and clothing. They work at kitchen and garden labor, in crews that gather oysters or crabs for sale in Darwin, as hunters, and as hands in the sawmill or on construction projects. Tiwi children have attended school since 1954 (page 420).

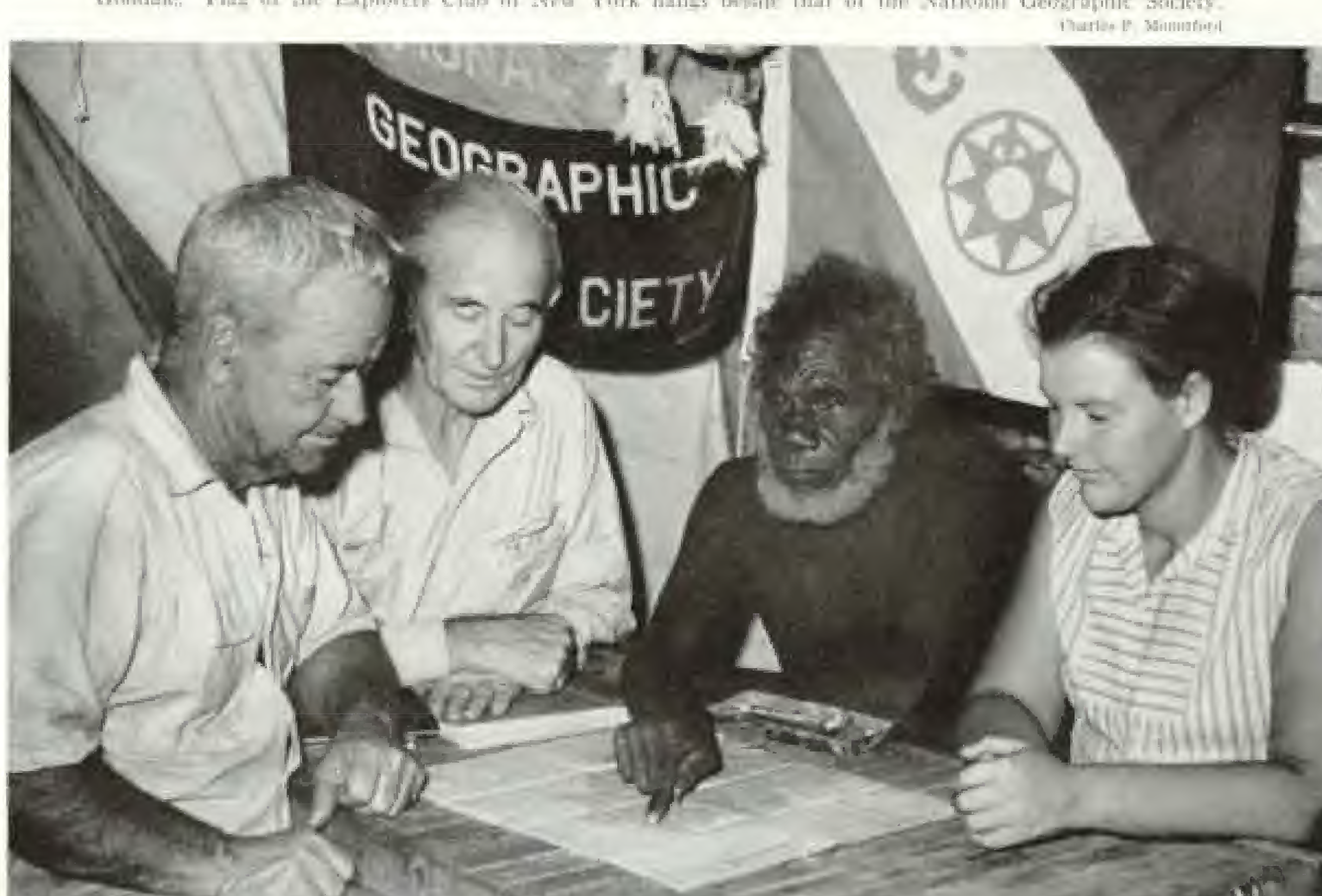
But the Government does not interfere with the ceremonials and personal life of these remarkable people. Moreover, at intervals it frees whole families to "go walkabout," to resume for weeks at a time the primitive life of the bush. Thus civilization has made little inroad on the Tiwi of Melville. We were still able to study Tiwi culture largely as it has existed since the Stone Age.

On a bush trip with a number of the Tiwi we saw more of their natural way of life than was possible in the settlement or around camp.

Expedition Members Hear the Story of Creation from Jamalumpua, a Tiwi Elder

Jamalumpua points on Melville's map to the spot where a mythical character brought death to the newly made world. His listeners are guide Bill Harney, author Charles P. Mountford, and ethnologist Jane Goodale. Flag of the Explorers Club of New York hangs beside that of the National Geographic Society.

Charles P. Mountford



← Tiwi Tribesman Wears a False Beard as Disguise Against a Ghost

Funeral ceremonies provide the chief social and artistic activity of the aborigines. Death corroborees, or dances, continue for months after each burial, until the final ritual, the *pukamani*, can be held. Such prolonged ceremonies are necessary to set at rest the deceased's spirit, which is regarded as evil (page 436).

Here, after five hours of make-up, Wurarbuti stands ready to lead the final ritual dance for his late uncle. His body has been rubbed with charcoal, then painted with a shirt of ocher and clay; ocher powders his hair. His attire is complete with a topknot of cockatoo feathers, a beard of goose feathers set in beeswax, and a ball of goose down suspended from the neck by a rope of human hair.

This costume is designed to prevent the dead man's spirit from recognizing Wurarbuti and harming him.

© National Geographic Society   Kodachrome by Charles P. Mountford

Melville Is the Tiwi's Sanctuary; Australia Allows No Exploitation →

Until about half a century ago the Tiwi knew little of the outside world except for Malay fishermen who occasionally came hunting sea cucumbers. Their isolation was heightened by fear of crossing stormy Clarence Strait in their frail bark canoes.

Melville and Bathurst have been deeded in perpetuity to the Tiwi. Today a handful of white people live at the Government station on Snake Bay, where Melville's 180 Tiwi receive food, clothing, and education. A mission at Garden Point cares for half-caste children from all over the Northern Territory.

Some 700 Tiwi on Bathurst are closely supervised by missionaries.

Mist rose from the bay as we put off in our dugout canoes. The early morning hours were decidedly chilly, even though we were in the tropics.

The paddlers worked steadily, first six strokes on one side, then a quick shift with no loss of rhythm for six strokes on the other.

As sun and breeze dispersed the mists, we could see the shores standing out clearly, strips of sparkling sand broken here and there with dark green where a mangrove-lined stream reached the open water. We passed a steep cliff showing bands of red and yellow clay—the ochers so prized by the Tiwi for painting their bodies—and a crown of ironwood, woolly-butt, and other eucalyptus trees.

Leaving the open bay in the afternoon, our canoes entered the mouth of a quiet river. A tall stork, the jabiru, one of the Tiwi totems, caught crabs and mudskippers as they scurried over the surface of an exposed mud flat. A flock of ducks took alarm and flew noisily away. On the far bank a crocodile—another totem—woke from his sunning slumber and slithered off the bank.

Now we were in a world of green, moving swiftly with the incoming tide. On each bank mangrove trees spread roots into the water, crossing over one another in intricate patterns. Oyster colonies clung to the hanging roots like bunches of grapes.

Mystery Lurks in Mangrove Jungle

Brightly colored birds chattered in the trees, and occasionally a clacking sound issued from the tangled mangroves. Otherwise it was a quiet and mysterious world, accessible only by water. One could easily imagine that the *Ningawi*, a fairy people who stoop as they walk and speak a strange language, truly did lurk in the thick jungle, as the Tiwi fear they do.

As the river wound through the tunnel of green, growing ever narrower, one of our paddlers suddenly laid his heavy ironwood paddle aside and reached for his spear—a slim pole tipped with three iron prongs salvaged from antisubmarine mesh. A quick throw, and a fish lay flopping in the boat.

Presently a rare stretch of solid ground

Posts Like Totem Poles Honor the Dead on Melville Island

A dead Tiwi is not properly buried without carved and painted ceremonial posts surrounding his grave. He may have a dozen or more markers, depending on his prestige. Taboo says that close kin may not make these grave ornaments; distant relatives are hired to do the work.

Above: Carved posts are planted in the ground near the grave ready for painting (opposite).

← In an earlier step, axmen carve the poles from bloodwood, a hard, red-sapped tree that resists termites and rot. Decorations have little symbolic significance and do not ordinarily resemble animals or birds. No two poles are alike; some are 20 feet high (page 434).

→ Carving finished, workmen scorch the logs to prepare a black surface.

© National Geographic Society

John C. Goodale

Aboriginal Artist Paints Gay Designs on a Burial Marker

Of Australia's many tribes, none except the Tiwi makes grave posts like these. No others duplicate the forceful designs with which they decorate their gifts to the dead.

Each Tiwi craftsman paints his own patterns on the pole he has carved, working as painstakingly as a tombstone cutter with marble. He seems unconcerned that the monsoon rains may wash away all his efforts within a few months.

A fixative—sticky beeswax, orchid sap, or the white of turtle egg—is smeared on the charred surface to make the paints stick better. Pipe clay serves for white; ocher is yellow or red. Pigments are pounded into powder and mixed with water in tin lids, crab shells, or folded leaf cups.

Today's Tiwi occasionally use oil paints, which produce more garish hues than the earth colors traditionally favored.

This artist chews the end of a stick to make an acceptable—and disposable—brush. He carves a wooden comb to produce quick rows of dots.

© National Geographic Society

Charles P. Mountford

Jane C. Goodale

Dolly Skins a Stringybark Tree

Stringybark is to the Melville islander what birch bark was to the American Indian. The half-inch-thick inner layer makes baskets and crude lean-to shelters. In times past it covered canoes. Dolly was house girl at the expedition camp and chief informant for Miss Goodale's study of Tiwi women.

unencumbered by jungle offered a camping site. Others had taken advantage of it previously, as old fires and remains of bark shelters bore witness.

A fire was soon started—with matches, although any Tiwi can readily make fire by twirling a hardwood drill between his palms.

Tea was the first order of business. One of the native women dipped water from the near-by billabong with her billy, a five-pound corned-beef can with a wire handle. As soon as it boiled, she tossed in a handful of tea leaves. With sugar added, it was ready to pass around.

Wall of Flame Aids Hunters

After a camp spot had been cleared, one of the aborigines set fire to the shoulder-high grass around the clearing. It burned intensely but briefly as the wall of flame raced away, and only an occasional dead log continued to smoulder in its wake. Hunters burn off the land every year in this fashion, turning the bush into a brown parkland in which they can easily see wallabies hopping through the trees, or locate the hollow-tree homes of bandicoots and possums.

Next morning the men were off early for the hunt, some of the women accompanying them. Other women took their axes and searched for stringybark trees. Tapping until they found a tree with loose bark, they chopped two deep rings several feet apart around the tree and connected them with a vertical cut.

Carefully skinning off the entire ring, they stripped away the rough outer layer and put the inner bark to soak. When it had become flexible, they folded it into a sacklike basket while holding it over the smoke of a fire. Then with a sharpened wallaby bone they punched holes along the sides and sewed them together with strips of vine (page 430).

Now the Tiwi use these bark-slab baskets chiefly for ceremonial purposes (page 434). For most other needs they prefer a calico or flour-sack carryall. Basket weaving has only recently been introduced, though the natives make woven pandanus armlets for use in rituals.

The search for tucker (food) occupies most of the time of both men and women when in the bush. Women dig yams with sharpened hardwood sticks or long iron rods flattened at one end. They collect oysters and crabs and cockles and snails; gather the bulbs of water lilies; chop holes in hollow logs to capture bandicoots and possums; or dig for goannas

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Jane C. Goodale

↑ Stamping Feet Raise Clouds of Dust Beating Rhythms of the Shark Dance

Tiwi death dances often portray animals of tribal mythology. Hands waving like fins, these actors pantomime the shark. Onlookers beat thighs and buttocks while chanting the fish's song. Bereaved spouses always perform this dance during the pukamani.

↓ Lunch on Banjo Beach: Taboo Prevents This Mourner from Feeding Himself

Funeral law forbids survivors to handle their own food and water, to wash, or to cut their hair until grave posts have been carved and pukamani ceremonies finished. Here Wuraributi, in mourning paint which he renews daily, gets a shellful of water from Yam-yam.

Charles P. Mountford

Bark Paintings Tell Tiwi Myths →

Tribesmen painted these designs especially for the author on slabs taken from the stringybark tree (below and page 425). The work symbolizes folk tales, such as the story of creation. This old favorite relates how Pukwi, the first creator, rose out of the ground and, crawling on her hands and knees, cut the channel between Melville and the mainland.

Another story concerns the Sunwoman, who lights her bark torch every morning and travels across the sky gathering food. At noon the heat from her cooking fire often drives men into the bush.

On the western horizon Sunwoman puts out her torch and, guided by light from its glowing end, returns to the east through an underground passage. Morning and evening, as she powders herself with ochers to please her husband, some of the dust flies into the air and tints clouds scarlet.

← Tamaluka decorates a ceremonial bark basket.

Jane C. Goodale (left) and Charles P. Mountford

and other lizards. The tender heart of the cabbage palm and "sugar bag" (wild honey) are relished; so are the bitter nuts of the palmlike cycad, which must be soaked for three days before use. Rats and carpet snakes, or pythons, are welcome.

Men go after larger game. They occasionally kill one of the few remaining buffalo, and wallaby, dugong (sea cow), sea turtles, alligator, and fish fall prey to their spears and sticks. They collect turtle eggs, golf-ball size and leather-shelled, which they roast or boil.

Most remarkable was the hunters' skill in downing geese with throwing sticks. These arm-long weapons are soaked for weight and "cooked" over a fire to give them magical properties. The fowler aims for neck and wing as the flocks go over at dusk.

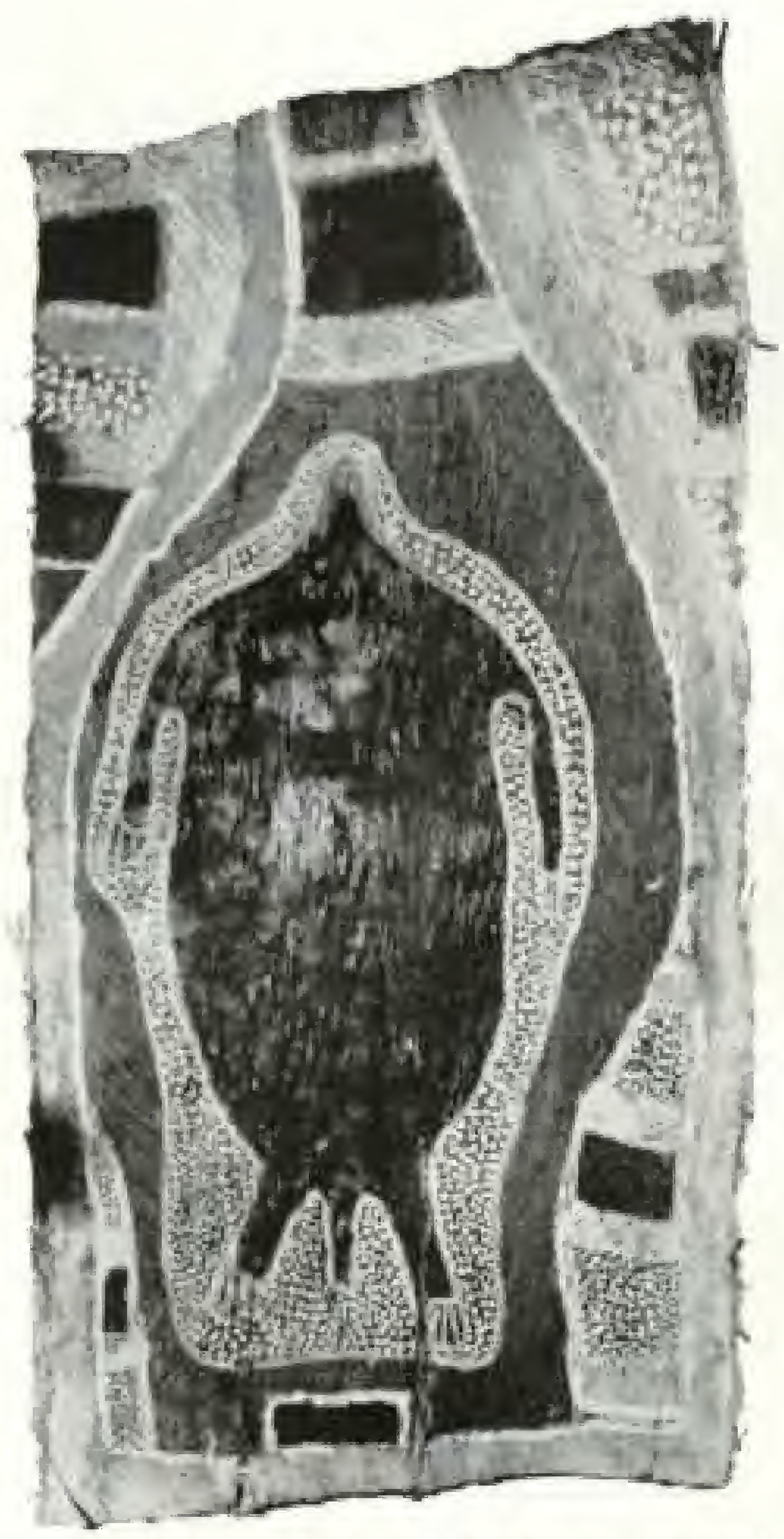
Even when an aborigine was able to use a gun, he stalked his game until he was within spear range.

Cooking is a simple matter for the Tiwi. This is best illustrated by the recipe for roast lizard as Miss Goodale recorded it:

1. Catch one lizard, any variety, by hitting with a stick;

2. Make small fire and, when burning well,

Along the Sands of Melville's Banjo Beach . . .



...Workers Tote a Harvest of Stringybark Sheets to Make Baskets for the Expedition

Charles P. Mountford

3. Throw lizard on top;
4. Turn frequently till well charred;
5. Eat all.

Baking the food of the white man is, for the aborigines, as casual as roasting meat. Flour and water stirred in a billy with a stick and kneaded into a thick, flat cake, two feet across, is simply buried in hot sand. When the unleavened loaf, known as damper, is baked, loose sand is knocked off the hard crust, and the day's traveling ration is ready.

Smoked Dugong Tickles Palates

The cooking by our own expedition member George Joy was considerably more professional. Many of the foods were new to him, and sometimes he had to seek Bill Harney's extensive knowledge of bush cooking, but his stuffed leg of wallaby was food fit for the gods, while his smoked dugong flesh, roasted flying fox, and turtle-egg omelet would delight the most exacting epicure.

In the evenings at our bush camp the Tiwi sat smoking stick tobacco in their crab-claw pipes as they thinned canoe paddles or scraped beautiful ceremonial spears whose many barbs represent the alligator tail (page 439).

And often they gambled at the game Ten High with civilization's cards till it was too dark to count the spots. I never mastered all its intricacies, but the natives played the game swiftly as they slapped down the cards and wagered sticks of tobacco, pieces of calico, or articles of clothing. Their standard of value showed how little private possessions meant to them, for *one* item, no matter what its intrinsic worth, was equal to any other item being wagered.

Outsiders rarely go to Melville, yet we had visitors twice while we were there. Associate Justice William O. Douglas of the United States Supreme Court dropped in on his round-the-world flight. And Dr. Carleton S. Coon, anthropologist of the University of Pennsylvania, came with his wife for 10 days to gather physical data about the Tiwi for his world-wide survey of the races of man.

Dr. and Mrs. Coon made extensive body measurements of the Tiwi (page 419). In addition they took skin temperatures, trying to determine how the natives adapted so well to hot days and cold nights. This information they turned over to the United States Army Quartermaster Corps, which is studying ways to protect fighting men from extremes of heat and cold.

When Dr. Coon first started work, the aborigines were fearful of his bewildering array of instruments. After a few days, when those who had submitted came to no harm, they all flocked to be measured and—incidentally—to receive their presents of money and tobacco.

Strangers Are Suspect

A stranger in an aboriginal community is a rarity and a suspicious character, for in such a tightly knit organization everyone is related to everyone else, however distantly. When the stranger enters camp, he must identify himself as to purpose and kinship.

When we arrived at Snake Bay, we too had to identify ourselves in this manner. We explained our purpose as "writing a story for a magazine with pictures." Since we had with us some examples, the natives accepted this explanation and gave us information.

Establishing kinship, however, took a longer time. One day, after we had been on the island a month or so, Miss Goodale and I were talking to Wurarbuti and his wife Kinani. At some point in the conversation Wurarbuti announced that Jane was his sister and that I was a brother of his wife.

Now, since all the Tiwi belong to one of about two dozen totems, each distinguished by the name of an animal, plant, or mineral object, and each passed down from mother to child, Miss Goodale became a member of Wurarbuti's group, the flying fox, and I found myself a member of the fire group.

To be made an honorary member of an aboriginal group was indeed a compliment. The privileges and duties of those born within the tribe were not extended us, but we were no longer regarded as strangers. We were considered, instead, friends and temporary members of the tightly knit Tiwi society.

Page 452

← Climbers Drop Through Smoke and Flame as Purification for a Funeral Ritual

Melville aborigines are splendid physical specimens. Most show a striking lack of fat. Around the settlement they often wear Western clothes issued by the Australian Government. For rituals and bush life they prefer loincloths.

The Tiwi believe that singeing the hair from arms and legs during ceremonies drives away evil spirits and protects against injury, sickness, and broken bones.

As each of these men drops down the tree trunk, his companions shout the name of his totem animal or bird with appropriate sound effects.

© National Geographic Society Jane C. Goodale

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Grieving Relatives Dance in Frenzy at the Climax of a Funeral Ceremony . . .

Nagranini (right) performs the basket dance; his partner carries a checkered bark-slab basket that will be left on the grave. Tinkiri (far left) wears a woolen ball, mainland version of the goose-feather ball (page 424).

Jane C. Goodale

. . . While Harlequin Columns Look Down on the Grave Like Silent Mourners

Tribesmen slash their heads with knives or sharp stones. Dancers vie in displaying steps and songs of their own creation. Onlookers shriek, clap, and chant. Women take part along with the men.

In this way we immediately acquired a whole camp full of parents, grandparents, brothers and sisters, cousins, and even wives, children, and grandchildren. Now, as I walked through the camp, I would be greeted, "Good day, Iringnari," by a stalwart, bearded young man in his early twenties, and I realized that this man was my "son." Or even more startling would be an introduction to one of my "fathers," a tiny infant 4 weeks old.

Mourners "Attack" Their In-laws

Strangely, during part of the *pukamani*, or funeral, ceremony, it is customary to arm one's self with leafy branches and attack with vigor and hilarity the family group of one's spouse. Soon after we became totem members, we were present at such a ceremony. Wurarbuti's wife came charging up to Jane and said, "Your brother, Wurarbuti, go help him." Miss Goodale gathered some branches and entered the raging battle, as did I. Not knowing all our relatives, we sometimes struck the wrong persons, and all laughed loudly at our error.

Early in our stay the aborigines performed the *kulama*, a ceremony centered around the bitter kulama yam and the initiation of young men and women. It is held each year at the end of the "wet," the rainy season.

One of the outstanding differences between Australian and Melville Island aboriginal cultures is the social status of women. On the mainland women are rigidly excluded from all but minor aspects of ceremonial life. Melville women, whose status almost equals the men's, are admitted to all phases.

Most of these rituals concern the preparation of the yam as food. In the one we saw, fully initiated men built the earth oven, gathered the yam in the jungle, cooked and soaked it in water. Their faces and bodies were elaborately painted.

Ritual Songs Used Only Once

The proceedings were quiet and dignified; there were few spirited dances. Each performer chanted a simple refrain with a narrow range of notes, a song used only once and then "thrown away."

The words covered many subjects. One man sang about the mean behavior of his mother-in-law. Another chanted about how a spirit child, a *pitipitui*, came to him while he was asleep, and asked to be directed to its future mother. The aborigines believe that all their children were once tiny pitipituis, who lived in colonies at various places in the islands.

Wurarbuti told how he had danced before the Queen of England:

"Queen was talking in England. He said, 'I want one native boy who was working in the army. Expect him to go to Brisbane to dance for me.' King Philip was looking hard at me when I danced very good. I was singing into a loud speaker."

But the most important ceremony of the island, and the one which not only occupies the attention of the aborigines for months on end but provides them with a complete outlet for their cultural expressions of art, music, dancing, and drama, is the pukamani burial ceremony. It climaxes a lengthy series of rituals, or corroborees, extending over months.

To investigate the pukamani, to record its beliefs, dances, music, and the symbolism of its designs, was one of the reasons we came to Melville Island. This research was urgent, for missionary influence and contact with civilization will eventually destroy it.

The Tiwi hold a deep-seated fear of the spirit of the newly dead, the *mapaditi*. For that reason the dead one's name is not mentioned for years. Near relatives refrain from approaching the grave during the months-long ceremonial period. If one did, the mapaditi, lonely for companionship, would steal his spirit to keep him company.

Menaced by a Spirit

One time the aborigines thought that the mapaditi of a dead woman, Nulatini, had stolen my spirit. The women, all agog with apprehension, told Bill Harney that I was in considerable danger, for Nulatini had called my name three times while she lay dying.

The men warned me never to go into the jungle by myself, never to walk around the camp without a light (the spirits of the dead fear light), and always to be sure that my mosquito net was well tucked in at night.

"If that woman, Nulatini, bin steal your *immunku*, you bin die!" they said.

So for weeks afterward, whenever I left the camp or was returning from one of the ceremonies, which were held about a mile away, I was always accompanied by one of the men.

Then came the day when, unknown to the men, I left my tent and walked along the shore of the lagoon to photograph water lilies.

I had not quite reached my destination

Facial Dots and Lines Are Tiwi Vanities

→Melville Island elders wear the old-style fringe beard, plucking other facial hair. For a ceremonial occasion such as this, the beard may be stiffened with a sticky sap and daubed with ocher, or covered with a false beard of feathers.

Painting becomes more elaborate at each stage of the funeral rites. Before the final pukamani, participants spend most of a day decorating one another with supple twigs dipped in ocher and clay.

Lower right: Even youngsters get the full-dress treatment.

© National Geographic Society
Charles P. Mountford (right and below);
Jane C. Goodale (lower right)

↑ Pickaback Youngster Enjoys the Funeral

Rachel fondles a goose-feather ball as she rides aloft. Her father wears scars—marks of beauty—on arms and chest.

A Pet Barn Owl Perches on June Goodale's Shoulder

Though Melville Island has no barns, it has barn owls similar to those in the United States. This young one, still unable to fly, became a pet of Miss Goodale. The bird came to an unhappy end when its liking for meat led it to kill a baby wallaby whose Tiwi owner took quick revenge.

David Parsons, the expedition's ornithologist, worked with the Mountford group on Melville and gathered birds on the mainland for Yale's Peabody Museum of Natural History. He skinned and stuffed these specimens outside the camp mess hall.

← Pooh the Possum Rides Aloft

This Australian variety of possum clings to 13-year-old Jennie, youngest married woman in the Tiwi settlement. Another of Miss Goodale's pets, it loved nothing better than to ride in her hair, with tail curled around her nose.

Charles P. Mountford

when I heard the men excitedly calling my name. Realizing what was the matter, I did not reply to them, but returned home by a roundabout way, hoping to learn more about their beliefs.

The men had followed my tracks till they lost them on stony ground. This convinced them I was in danger, for when a mapaditi steals the spirit of a living person, that person becomes unconscious and his body invisible. Being able to walk a few inches above the ground, he leaves no tracks.

The aborigines believed they had saved my life, that when Nulatini heard them calling out, she released my spirit.

The pukamani corroboree, with its elaborate and extended rituals, its painted baskets and burial poles, is performed only on Melville Island.

No Western artists could take more care or gain more enjoyment from their art than do those who carve the poles for the ceremony. The deliberations with which they paint their apparently meaningless patterns, using crude brushes of chewed twigs, and the air of quiet contentment in their primitive outdoor studio, would convince any observer that these men experience deep pleasure from their creative effort (pages 426 and 427).

The painted poles, erected around the grave at the final ceremony, with the decorated baskets placed on top, are a present to the spirit. These presents and the final mourning rituals are all designed to put the newly dead spirit happily at rest, so that it will no longer be a threat to the living.

During the pukamani men and women enact mythical stories of the fairy people: the Ningawi, who still live in the mangrove swamps and steal lone women; the frog-woman, Quork-Quork, and her three daughters—Pakadringa, the rain, Bumarali, the lightning, and Tomituka, the monsoon; and the sea-eagle, Yirakati, swooping down on his prey.

During these dances the onlookers excitedly beat time on their buttocks and gave voice to the shrill tremolo—unlike any other sound on earth—that they label the "mosquito call," and to the lower pitched, long-drawn-out o-o-o-o known as the "honey call."

Tiwi Stage Wild West Dance

Part of a ceremony we witnessed consisted of secular dances that portrayed the episodes of everyday life: how Zamat made his bark canoe, how Komoni speared his first dugong, and how Sepnauti went on an alligator hunt (page 429).

At one corroboree Wurarbuti led a cowboy theme which went on for several dances. The participants "stuck up" banks and other riders, imitating a Wild West movie some of the Tiwi had seen in Darwin.

Early in the evening the dancing stopped and everyone retired to rest. All through the night the chief mourners and some of the workers alternated in singing songs about the departed relative.

At dawn the ceremony, starting afresh, led to the closing phases of the long-drawn-out pukamani, when the living said farewell to the spirit of their old companion.

Before the coming of white men, pole carv-

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A. J. Lowery

Charles P. Mountford

Wurarbuti Hurls a Fighting Stick; He Holds a Talisman in His Mouth

Melville Island aborigines make matched sets of fighting sticks from ironwood, striving for equal weight and balance. They aim a weapon at the ground about 20 feet in front of the target, considering it more difficult to dodge on the bounce. In former days a fighter tucked beard in mouth to make himself more ferocious. Wurarbuti uses a feather ball for the same purpose (page 424). Actually the Tiwi are more good-humored than savage. Woven pandanus rings on elbows are a sign of mourning.

ers were paid in spears, throwing sticks, and other implements. Now payment is in the goods of the white man—squares of printed calico, used as loincloths, tobacco, and smoking pipes.

At "pay" time the leader sat atop a pole, resplendent in his body paint and decorations. He called to each worker, thanked him for the beautiful pole he had cut, and recompensed him for his work.

While I was busy photographing the dancers, I heard my name called. Starting a song and beating their thighs, the aborigines demanded that I perform a dance in acknowledgment of a gift of ceremonial ornaments we wanted for the expedition collection. I did so, much to the amusement of my companions.

As the rituals neared their close, the women washed off their paint to end the taboo. They sobbed heartbrokenly. The chief mourner, son of the dead man, cut his head until the blood flowed down his face; then he collapsed on the ground in a paroxysm of grief.

A scene of mass hysteria and weeping followed. Women, beating their bodies with sticks, threw themselves on the ground, and men wailed continuously.

Gradually the sounds of sorrow became less. One by one the mourners left, until there remained only the crouching body of the aging widow, a small, wizened woman whose span of life was almost spent.

Two Cultures Fuse

Sometimes the Tiwi sing in their rituals about airplanes and steamships and the machines of warfare they saw when Japanese planes attacked Australia. And children at school sing "The Old Gray Mare She Ain't What She Used to Be!"

At first glance this would indicate that Tiwi culture is giving way to the impact of the world. But such is not the case. To a remarkable degree the Tiwi accept what they want from outside without letting their own way of life disintegrate.

For example, when these archaic people go into the bush they revert to the life of their ancestors, except that steel replaces stone in their axheads.

We left this faraway island genuinely fond of the Tiwi. Whatever may happen in the future, my devout hope is that their gentle and friendly qualities will not change.

INDEX FOR JULY-DECEMBER, 1955, VOLUME READY

Index for Volume CVIII (July-December, 1955) of the National Geographic Magazine will be mailed upon request to members who bind their copies as works of reference.

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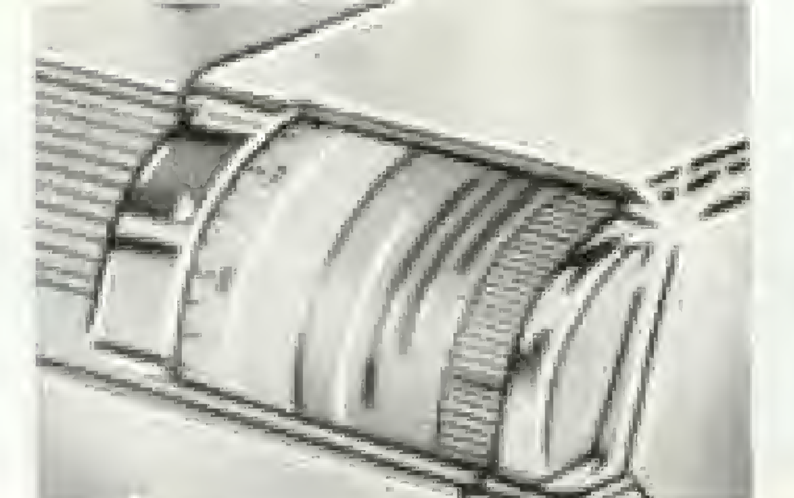

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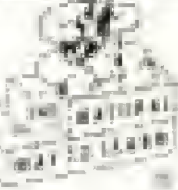

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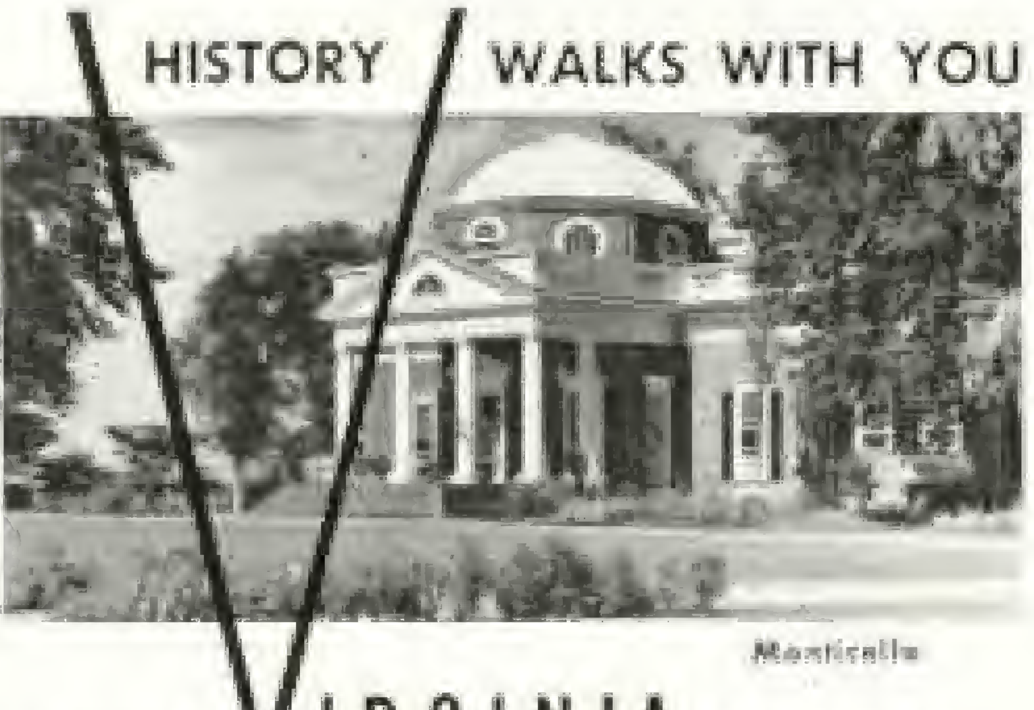

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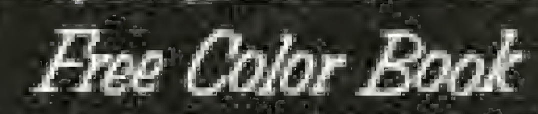

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